THE ENGINEER

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STATE SCHOLARSHIPS

It is good to learn that the Government has decided to increase grants to state scholars and still better that it will ask for smaller contributions from parents. At the end of last week details were announced by the Minister of Education. Grants are increased by amounts between £20 and £40, dependent upon the university being attended and whether the student is living in college, in lodgings or at home. On the parental side, the " means test " which is applied has been so eased that for the richer parents some £100 per year will be saved. In calculating the " scale income " from which the amount of the parental contribution is derived, various allowances, including life insurance premiums and mortgage interest are deducted from the gross income. The allowance for each dependent is now raised from £150 to £170 ; that for educational expenses and school fees becomes a maximum of £180 instead of £150, and for university education or professional training a maximum of £350 instead of £300. The scale from which the contribution is calculated by reference to the " scale income " has been adjusted so as no longer to become progressively more severe as incomes increase. No contribution will be required from parents with a " scale income " below £525. At that figure the contribution becomes £10 and thereafter the contribution increases by £14 per £100 of " scale income." The cost to the Exchequer is expected to amount to about £1,900,000 in a full year.

The changes are certainly in the right direction. But they do not seem to us to go sufficiently far to meet the criticism that professional people cannot always now afford to send all their children to universities. It is to be noted that the economy to parents under the announced changes amounts to not more than £10 per year until the " scale income " exceeds £1500 a year. At that level the parents are expected to find £147 per year, not, we imagine, by any means an easy task even if there is only one child, but very much more difficult if there are more than one. Parents with a " scale income " of £3000 have to find £357 under the new scale, as compared with the whole cost before, again by no means an easy task when more than one child is involved. But we do not believe that tinkering with the methods of calculating allowances is ever likely to put right the anomaly existing to-day that no child of professional parents, however bright and intelligent, can feel as sure of attaining a university education as a child of parents of more limited means. Children of richer parents are thereby made not " privileged " but " under-privileged." In this supposedly enlightened age, surely it should be recognised that, so long as commissions and committees continue to stress the shortage of highly-trained people in industry and elsewhere, no young person fitted to benefit from a university education should be prevented from attending a university, solely because the parents are unable or unwilling to pay in whole or in part for it. The nation, in looking narrowly, like an accountant, to see whether it considers the parents capable of paying for the youngsters' education is really cutting off its nose to spite its face. It is far more valuable to ensure that every youngster capable of benefiting from a university training should get that training than to collect a proportion of the cost from the parents on the ground, presumably moral, that they are so rich that they ought to be able to pay. The nation makes no such moral distinctions about elementary education. The principle is recognised that it benefits the nation to educate all its children up to the age of fifteen. Would it not benefit even more by paying to educate all fitted for it up to a much later age, regardless of whether or not the parents ought on some accountant's or moralist's reckoning to be able to pay ? This would restore to richer professional men the privilege, surely by no means an unreasonable one, of ensuring, should they so desire, that their children are less straitened in income at a university than those solely supported by the State.

ROAD PLAN FOR LONDON

The British Road Federation was recently asked by the London County Council to suggest the sort of highway development it would like to see in the revised County of London Plan due in 1961. That Federation is regarded by some people as a somewhat extreme body, a kind of pressure group attempting to get more money spent on road development than is really deserved. But the submissions it has now made to the L.C.C. give, in our opinion, no support to that view. True the proposals made would prove very expensive to carry out. But anyone who has studied London's traffic problems, whilst remembering how rapidly the number of vehicles on the roads is expanding and whilst bearing in mind the high probability that within a couple of decades there will be as many cars per head of population here as there are already in the United States, can feel only the urgent need to make a real start at once upon improving access to the centre and towards a solution of the parking problem. Under the Federation's plan, there are two main provisions. First, there ought, in its view, to be a limited access highway encircling the central area approximately on the line of the present " A " ring road ; and then there should be constructed radial limited access highways from the ring road to the St. Albans by-pass (thus connecting with the Birmingham motorway now under construction), to Western Avenue, to Eastern Avenue, with a spur to the docks area (thus providing motorway conditions all the way from the Midlands to the London docks) to the Great West Road at the new Chiswick fly-over and to Rochester Way. Additionally, the Federation believes that in many outer areas the principle of by-passing should be employed to relieve the traditional High Streets of the villages and towns which, in the course of time, have been absorbed in the London Area of through traffic, thus permitting them to revert solely to their still existing function of shopping centres.

In making these and certain other proposals the Federation makes a distinction within the London area between local and through traffic. It is the considered view of the Federation, with which we think all urban highway engineers will concur, that all future roads constructed for through traffic should be built with limited access—that is, as urban motorways. The Federation thus regards the Cromwell Road Extension, despite its fly-over at Hammersmith and Chiswick, as already out of date and defective for its purpose. It also appears to the Federation, as, again, it will to highway engineers, to be illogical to terminate in-reaching limited access roads on a network of existing all-purpose roads. Effectively, either by having a ring road around the centre, or by other means, there must be an extension of each such radial road right across the centre. Further, the Federation regards as suspect proposals for local single level improvement of existing road junctions, such as those at the Holborn–Kingsway intersection and for St. Giles Circus. Good modern practice, it is suggested, calls for two-level treatment. We cannot help but concur. For it does not pay to play for economy in building new roads or improving old ones. Scarcely any of the roads built shortly before the war and then regarded as fine of their kind can now be regarded as adequate in width or general layout for the traffic they carry. For in building a road one is building not for the present, not even for conditions twenty years on, but for the almost unlimited future ! In any new urban roads to be built in the next four years the design should not be conservative. It should provide for the amount of traffic likely not merely ten or even twenty years on, but for the conditions, as nearly as we can imagine them, likely to exist fifty years hence or more.

But the construction of such an array of urban motorways as the Federation proposes, not to mention the local by-passing of High Streets and other shopping centres and construction of two-level crossings at places in the central area, must prove immensely costly. The Federation has not attempted to count the cost. We applaud that magnificence even though we feel forced, as good engineers, to condemn it ! For we agree with the Federation that it is essential that any Plan for improving London's roads should be related to the need and not geared to " a wholly inadequate programme of finance " ; and we also are convinced, like the Federation, that the economic return upon a proper reconstruction of London's roads will be very high. Nevertheless, it is the job of engineers to count the cost in relation to the benefit ; to endeavour to select that scheme which confers the most benefits at the least cost ; and to lay down a programme of priorities so that schemes providing the most relief at least cost are those first carried out. But the Federation no doubt does not regard such computations as its tasks. It must be for engineers to work out what should preferably be done, whether upon the basis of the Federation's proposals or of some other set. What the Federation has usefully done is to show that the problem should be, and can be, faced on the basis of providing for the foreseen growth of traffic. To evade the issue by claiming that the expense cannot be afforded is merely to be irresolute.

NUCLEAR REACTORS FOR DESTROYERS

The Bill recently passed by the United States House of Representatives authorising the construction of a prototype nuclear reactor for the power plant of a destroyer marks another milestone in the development of nuclear propulsion for ships. The vessel will have a displacement of 7600 tons—a displacement which in pre-war days would have classified her as a light cruiser. But with the elimination of battle fleet actions destroyers are no longer required to attack battleships with torpedoes—or to counter such attacks. Moreover, with the much larger accommodation now required for an anti-aircraft guided missile armament, vessels of destroyer type will inevitably increase in size until they become virtually small cruisers. This, in fact, is what is happening now. Britain's new fleet escort vessels of destroyer type (which have yet to be laid down) are expected to have a displacement of between 4000 and 5000 tons—some 2000 tons larger than the 2600-ton " Daring " class ships, which were built and originally classified as destroyers. Similarly, although the Americans have still to complete some of their 2850-ton " Forrest-Sherman " destroyers, their new vessels of destroyer type with anti-aircraft guided missiles have a displacement equal to, or even larger than, that of our fleet escort vessels. None the less, whether a vessel of 7600 tons is classified as a destroyer or small cruiser, the practicability of constructing a nuclear reactor suitable for a surface ship of this size requiring very high speed indicates a technical breakthrough in the reduction of either weight or shielding. Because of the need for compactness and light weight, the weight-to-power ratio of her power plant must be very low—in the nature of the 60 lb to 65 lb per shaft horsepower of the modern conventional destroyer.

The 85,000-ton U.S. nuclear-powered aircraft carrier ordered last year, which is to be powered by eight reactors, will have great advantages in having no boiler intakes or funnels and in being able to carry twice the amount of fuel for her jet aircraft than the aviation fuel carried in conventional carriers of the same size. But there is little purpose in being able to steam for prolonged periods at 35 knots if her escorting vessels are unable to do likewise. The conventional destroyer steaming at normal peacetime speeds has to refuel every five to ten days, an operation which is to a large extent dependent on reasonable weather conditions. It is thus of enormous gain, both operationally and in the ability to maintain a Task Force at sea, that the escort vessels should be nuclear powered. But in the light of her present defence policy—concentrating on measures to prevent war rather than preparing to wage war—Britain for many years ahead can only hope to build vessels with a costly nuclear power plant which are best suited to implement that policy. The ideal deterrent—a rocket-firing submarine—must be left to the Americans, who alone can afford to build a type of vessel costing £30,000,000 or more which cannot do much to safeguard the sea communications. At the present time this country is planning to build only one nuclear-powered vessel—the " Dreadnought "—an experimental submarine. As soon as she has been completed—her keel has not yet been laid down and it may well be three or four years before she is commissioned—the Government will then have to make up its mind whether it is to pay more than lip service to the role of the Royal Navy in the event—unlikely, in its view—of a global war. For the nuclear power plant intended for this new vessel of destroyer type emphasises the probability—already indicated by the nuclear power plant of the medium-size U.S. submarine " Skate "—that we have now reached a stage where we can build relatively small nuclear-powered anti-submarine submarines. These vessels will, of course, be of great value as units of our general-purpose submarine force. But they will also be a logical development—a development which we can afford—of Britain's present defence policy. By reducing the threat of the Russian rocket-firing submarine, they will add considerably to the deterrent effect of the land-based United States and British strategic

bombers and of the United States intercontinental land-based guided missiles, ship-borne medium-range bombers and intermediate-range ballistic rockets fired from submarines or surface ships. Moreover, it should not be many years before Britain also produces a 3000-mile land-based ballistic rocket to replace the relatively useless "Thor" which we are shortly to receive from America.

A WATER POLLUTION ACTIVITY

We are delighted to see that the Water Pollution Research Laboratory is to issue quarterly a leaflet entitled "Notes on Water Pollution." The first such leaflet lies before us as we write. The purpose of the series of leaflets will be to discuss in not too heavily technical a manner various aspects of water pollution and the means of control, and to draw attention to more detailed publications on the subject which may be found useful. The first leaflet deals with the "Effect of Organic Discharges on the Level of Oxygen in a Stream." The series, it is to be noted, is intended primarily for circulation within industry, and its publication has no doubt been undertaken as a consequence of the substantial financial help which the Laboratory is now receiving from the Federation of British Industries and which will also permit it substantially to increase the value of its work on industrial effluents. It is peculiarly encouraging that the Federation should thus actively be co-operating with the Laboratory and helping the Laboratory to get its work better appreciated industrially. Those whose concern it is to fight pollution are often far too prone to believe that industrial firms pollute streams and rivers without any consideration whatever for the rights of others or of public amenity. Colour is given to that belief because, unless its attention is especially drawn to the matter, the management of a firm may not appreciate that it is responsible for discharging anything deleterious into a river; because a single offence arising out of the oversight of a servant of the company or of a failure of supervision or from accidental failure within the plant may lead to the wholesale killing of fish downstream; because some effluents are difficult or even impossible to treat; or because the firm is unaware that treatment is possible. The "Notes on Water Pollution" which the Laboratory is to issue should do much to enlighten industry as to how to solve its problems and to awaken interest also, we hope, in the possibility and desirability of solving these problems. For though, directly, it is an expense for industry to have to treat, fully, effluent discharged to a stream, or to treat, partially, certain effluents discharged to public sewers, indirectly an expense falls upon industry if it fails so to treat its effluents. For industry is a user of pure water as well as a potential polluter, so that the greater the extent of the water it pollutes the larger is the cost likely to be of securing supplies of clean water. We suspect, indeed, taking all things into account, including public health, that, nationally, it is cheaper not to pollute a country's rivers than to pollute them, just as it has become recognised in this and many other countries that the maintenance of clean, unpolluted air brings direct economic advantages far outweighing any incidental costs that may be laid upon fuel users. Some day, perhaps, it may prove possible to place on the Statute Book an Act as unequivocally requiring that this country's streams and rivers be kept free of pollution as the Clean Air Act requires that the atmosphere shall be kept free of smoke. But much more work will have to be done by the Water Pollution Research Laboratory before the drawing-up of such an Act (or the enforcement of its provisions) could be deemed within the limits of the possible.

THE ALDWYCH TUBE

A London Transport event, which has been rather overshadowed by the persistence of the bus strike, is the "partial retirement" of the Aldwych tube. The train service on this spur of the Piccadilly Line, which links Holborn with the eastern end of the Strand, now operates in the morning and evening rush hours only. The elimination of the service during the remainder of the day is a sensible measure at a time when the economics of passenger transport are of the highest importance. But the "partial retirement" of this short branch of the old "Great Northern, Piccadilly and Brompton Railway" is an occasion that we cannot restrain ourselves from mentioning. For, throughout the fifty-two years of the line's existence, we and our predecessors have been frequent customers. Often, in recent years especially, our many journeys to the Midlands and North, from St. Pancras and King's Cross, have started with a short trip in solitary state on the Aldwych tube. In the minute or so from Aldwych to Holborn we have talked with the guard of the two-coach train and have been left in no doubt that a turn of duty on the "Aldwych" can be monotonous! Nevertheless, it is a branch of London's Underground that has served the metropolis well. By no means the least of its service was during the second world war when Aldwych Station, and quite a bit of the line, formed one of London's most popular and well-organised air-raid shelters.

The Engineer — 100 Years Ago (JUNE 11, 1858)

"BIG BEN THE SECOND"

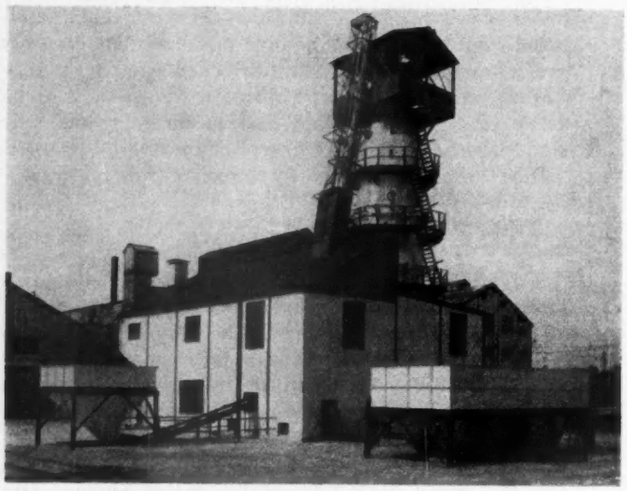
"Unlike his predecessors, the new 'Big Ben,' or, as it has been christened, 'Victoria,' is tastefully ornamented with Gothic tracery in low relief. On one side of his waist is the portcullis of Westminster, and on the other the arms of England sharp and clear, as if traced by the hand. Round the upper lip is traced in Gothic letters the following inscription:—'This bell, weighing tons, cwts. qrs., was cast by Mr. George Mears, of Whitechapel, for the clock of the Houses of Parliament, under the direction of Edmund Beckett Denison, Q.C., in the 21st year of the reign of Queen Victoria, and in the year of our Lord MDCCCLVIII.'

"The weight is rather over 14 tons, or 1¼ tons less than the old bell. Its height is 7 feet 3 inches, and in diameter at the mouth it measures 9 feet. Though there is less metal in the present bell than in the former, its dimensions are not less than those of its predecessor, though its form is slightly different. The head is more rounded, and the waist more sloped in. The sound bow, or place on which the clapper strikes, is also half an inch less in thickness than that of the old bell. The new bell is, like the old one, a little faulty in tone, i.e., it is nearly F instead of E natural, and will consequently necessitate the toning of the quarters to accommodate it. The tone of the new bell is stated to be so full of sound that a slight stroke even with a common switch makes it ring with a tolerable tone, and the vibration, after being struck with the clapper, gradually settles down like the sound of a trumpet slowly dying away. The clapper of the 'Victoria,' which is in readiness to be attached, is about half the weight of the one originally cast, being now about 6 cwt., instead of 12 cwt., as formerly. This huge bell, when hoisted in its resting-place, will not ring out in chime with its four neighbours, but deliberately and distinctly toll forth Time's succeeding hour."

Sugar from Beet

No. II—(*Concluded from page* 841, *June* 6)

Every year between 4,000,000 *and* 5,000,000 *tons of sugar beet are grown in this country on about* 400,000 *acres of agricultural land. The British home-grown sugar industry has a long history, though it is only in the last twenty years or so that it has become firmly established. Mechanisation of all stages of beet cultivation and harvesting has done much to further the industry's progress. Last week we dealt with the mechanisation of beet growing. Below we describe the manufacture of sugar from beet, with particular reference to the factory at Wissington.*



IN last week's article we outlined the history of the British Sugar Corporation, and its responsibility for home sugar production, including the operation of eighteen factories. In particular we discussed the business of mechanised beet production from the seed to the harvest and we showed that, in the season or " campaign " which ended recently, more than half of the total beet crop was harvested mechanically. The scale of these operations can be appreciated from the statement that about 400,000 acres, mainly in East Anglia, are under beet each year, giving an annual yield of between 4,500,000 and 5,000,000 tons of beet, from which the following products are obtained in an average year :—More than 650,000 tons of sugar, about 300,000 tons of dried molasses beet pulp, and 100,000 tons of molasses.

To see these figures in perspective, it should be recalled that the whole campaign is concentrated into about sixteen weeks from October to January. During that period manufacturing is, literally, a continuous process, each week consisting of seven three-shift days. Accordingly, during the campaign a typical factory must handle a daily throughput of the order of 2600 tons of beet.

The main particulars of the Corporation's eighteen factories are given in the accompanying table. It may be recalled that beet sugar manufacture has previously been referred to in these columns in articles describing the factories at Kelham* and Allscott.† Although the manufacturing processes have not altered fundamentally since 1927, when the second of these articles was published, there have been very considerable advances in techniques. The object of the present article is to outline briefly some of these developments and to describe in some detail the latest and perhaps most interesting of them—a method of applying an electronic closed-loop system of control to the process of sugar extraction from beet. However, before describing this control system, which has been installed for the first time at the Corporation's Wissington factory, we propose to give a short outline of the manufacturing process.

Beet Sugar Manufacture

Sugar beets are usually brought to the factory site by road. Samples are taken from each lorry load, washed and analysed for sugar content ; at a typical factory this process may involve 450 samples per day. Gross and tare weights and sugar content are among the data recorded. At the Wissington factory experiments are being carried out with the automatic recording of the required information on Hollerith punched cards. One method of unloading the lorries here is by water jets : the beets are stored out of doors in concrete silos.

As required by the factory the beets are sluiced along overhead flumes in which are a series of devices which remove adhering weeds and stones from the beets.

The beets are then taken along the open sluiceways to the factory building where they are washed. The magnitude of the cleaning operation can be estimated from the fact that it is not uncommon to have to handle and dispose of 250 tons of soil and stones (many of them weighing 2 lb or 3 lb each) from the daily throughput of beet.

British Beet Sugar Factories

Factory	Year built	Beet sliced, 1957, tons per day
Cantley, Norfolk	1912	4000
Kelham, Notts*	1921	1400
Colwick, Notts	1924	2000
Bury St. Edmunds, Suffolk	1925	5100
Ely, Cambs	1925	3300
Ipswich, Suffolk	1925	2500
Kidderminster, Worcs	1925	2500
Spalding, Lincs	1925	2500
Wissington, Norfolk	1925	2100
Cupar, Fife	1926	1900
Felsted, Essex	1926	2500
Peterborough, Northants	1926	4300
Poppleton, Yorks	1926	2300
Allscott, Salop†	1927	2200
Bardney, Lincs	1927	2400
King's Lynn, Norfolk	1927	2900
Selby, Yorks	1927	1200
Brigg, Lincs	1928	2200

In the factory the manufacturing process proper begins with the slicing machines in which the beets are cut into thin strips, which are V-shaped in section and are generally known as " cossettes." The slicing operation, which is referred to more fully below, is designed to produce strips as thin as is compatible with two main requirements (*a*) that they should not cause clogging, and (*b*) that they should present the maximum surface area to facilitate the extraction of the sugar-laden juices by diffusion, which is the next main operation. Before reaching the diffusion station the strips produced by the slicing machines are discharged on to a belt conveyor equipped with a belt weigher. As explained below, this weigher is arranged to control the output of the beet slicers according to the requirements of the diffusion process. To prepare the strips for diffusion they are discharged from the belt conveyor into a prescalder and a swim trough.

In the diffusion plant the strips are brought into contact with hot water, whereupon the sugar (together with some of the unwanted impurities) diffuses by osmosis through the cell membranes into the water. In the more modern plants diffusion is a continuous process brought about in a long, slowly rotating drum through which the water and the beet strips travel in contra-flow and in continuous contact, as described below.

From this point the progress of the exhausted beet strips and of the sugar-bearing water, or raw juice as it is called, can be followed separately. Taking the raw juice first, chemical treatment is necessary as part of the purification process. Filtration is the main means of purification, but it must be preceded by chemical treatment, because many of the impurities are colloids and must be precipitated for filtration. Chemical treatment is also required to neutralise the acidity of the raw juice, because the acids would otherwise cause the sucrose to decompose into glucose and fructose.

The first part of this purification is known as carbonatation,‡ or carbonation, and it consists of defecation of the raw juice (heated to about 85 deg. Cent.) by adding milk of lime and then by precipitation of the impurities by pumping through carbon dioxide. Both the quicklime § and the carbon dioxide required for this carbonatation process are made in lime kilns on the factory site.

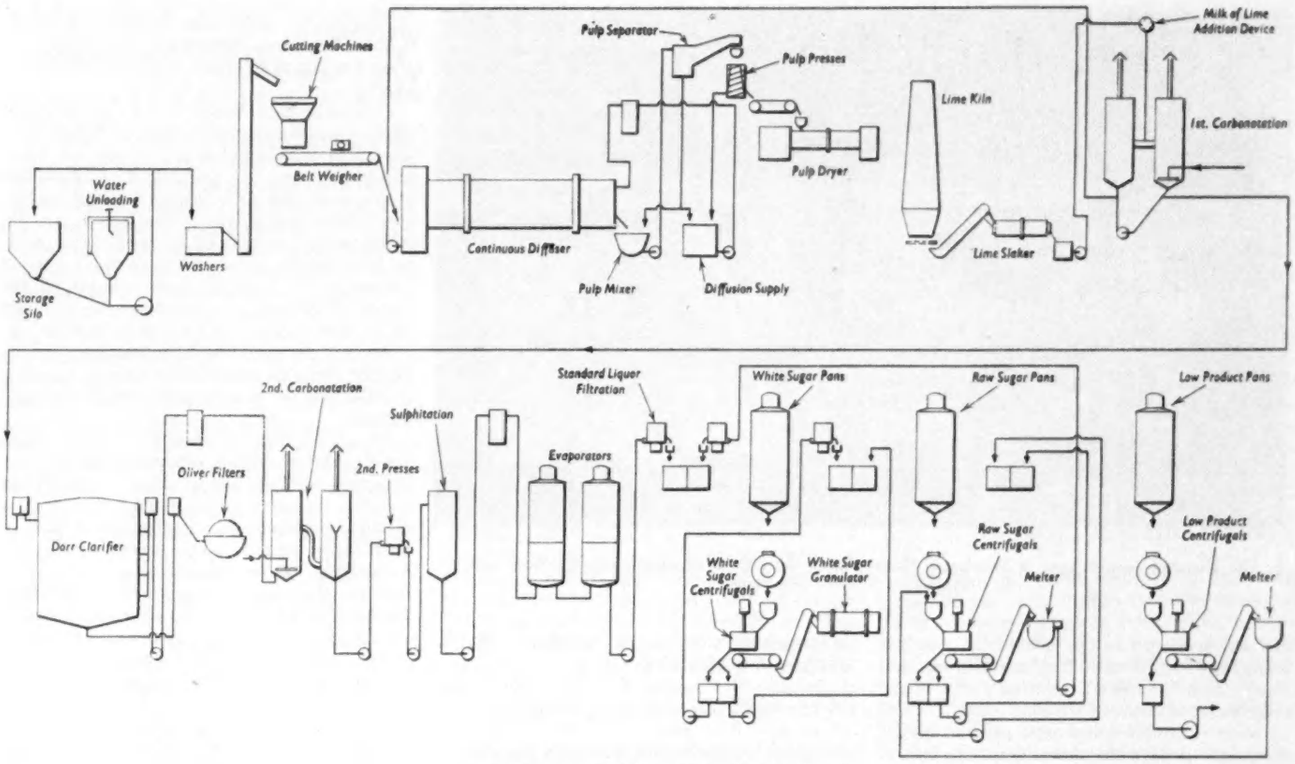
After this first carbonatation the raw juice is pumped into a Dorr clarifier, a large tank in which the impurities are allowed to settle as sludge and are drawn off by clack pumps. The sludge is finally separated in Oliver continuous filters. The supernatant liquor is pumped from the clarifier to a second carbonatation process, but without the addition of the milk of lime, and is then filtered. If the factory is producing white sugar, the juice is pumped in a sulphitation tank through which sulphur dioxide is passed to remove the small residue of lime, and reduce the viscosity in the final boiling operation.

The liquor, which at this stage in the process is known as thin juice, is then pumped to the evaporators for concentration by removal of the bulk of the water. Multi-effect steam-heated evaporators in series are used for fuel economy, the vapour produced in each vessel being used to heat the juice in the next.

Further concentration of the juice is produced by boiling under vacuum, again using vapour from the evaporators to make additional fuel economies. The formation and growth of the sugar crystals takes place in these vacuum pans. The pan is discharged

* The Engineer, August 18 and 25, and September 1, 1922.
† The Engineer, October 4 and 11, 1929.

‡ The form " carbonatation " is used throughout this article to indicate the French origin of the word and the process it describes.
§ In the Wissington factory the quantity of lime required is about 1·5 per cent of the beet strips.



Typical flow diagram of sugar beet factory

batchwise and the sugar crystals separated from the mother liquor in a battery of centrifugal machines. In each of these machines there is a fine-mesh basket which is rotated by an electric motor at speeds of 1000 r.p.m. or more, so that the syrup is spun off, while the crystals remain behind. The crystalline sugar is then fed into a granulator, to be dried and cooled ready for packaging or bagging.

In the meantime the syrup from the centrifugal machines is reboiled to produce raw sugar ; after repeating this reboiling the raw sugars from the two processes are again reboiled with the original juice from the evaporators.

To trace the progress of the beet pulp we return to the diffusers where the spent strips, having given up their sugar content to the hot water in the diffuser drum, are passed on to presses to remove some of the excess moisture and are then taken on a conveyor to large driers which are coupled direct to coal fired furnaces. There the excess water is evaporated. Generally the pulp is mixed with molasses extracted from the centrifugals and is bagged for cattle food. At Wissington approximately half the dried pulp is pressed into blocks. At another factory the pulp is produced as small pellets.

Wissington Factory

The recent improvements introduced at the Wissington factory sprang from the decision to replace the existing battery of Robert cells by an R. T. Bergé continuous diffuser. With this change, the whole manufacturing operation from the handling of beet up to the vacuum pans became a continuous process and, therefore, amenable to automatic control. At the end of this continuous process was the vacuum pan floor which thus determined the limit of productive capacity.

To obtain the maximum throughput from the factory an automatic control system was envisaged for the continuous part of the process. The system that was devised for this purpose by the British Sugar Corporation in collaboration with Evershed & Vignoles Ltd., is believed to be the first closed-loop electronic control installation applied to the process of extracting sugar from sugar beet.

This installation functions through a number of transducers for sensing flow, level, temperature and so on, and providing corresponding electrical signals which are either applied to Evershed three-term process controllers or used as inputs to Evershed analogue computers. Each of these computers gives an output signal which gives continuously an evaluation of the equation governing that part of the process to which it is applied.

Briefly, master control of the continuous process is made to depend upon the level of liquid in the thick-juice tank. This control is exercised through a level transmitter in such a way that if the level rises to within 18in of the top of the tank the flow of thick juice is reduced and so is the flow of thin juice to the evaporator. Similarly if the thin-juice tank level rises above a predetermined limit, as determined by another level transmitter, the flow of raw juice is reduced. Likewise, if the level rises in the circulating tank the quantity of beet and the supply of water to the diffuser are correspondingly reduced. To keep a smooth and regular flow a number of secondary control loops and checks are introduced into the system. Besides the quantitative controls mentioned above there are automatic controls to determine the quality of the process, which will be described in greater detail below.

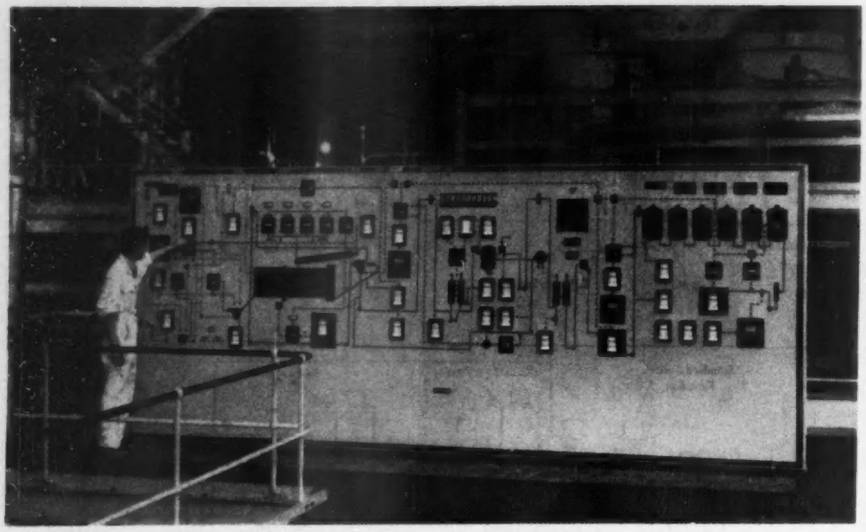
Supervisory control of the whole installation is centralised on a graphic control panel, on which there are a number of Evershed miniature recorders which provide a permanent record of the performance of the plant besides yielding information for accountancy and statistical analyses. By means of " Miniplaques " mounted on the panel it is possible to transfer smoothly from automatic to manual operation of the plant, if required.

To simplify the task of supervising the whole plant by a single operator use is made of the Evershed " In-Line " scanner which consists of a number of vertical strip indicators, each connected to the error circuit of a particular controller. The indicators are mounted side by side (at the top centre of the panel) in such a way that, when each controlled process is working perfectly all the indicators give an in-line reading. Any break in the in-line readings is readily detected and represents a departure from normality in some part of the plant; the indicator that is " out-of-step " identifies the faulty process and the divergence from the in-line condition is a rough measure of the error in that process. At present the panel contains eleven in-line scanners, which indicate respectively—thick-juice tank level, evaporator level, thin juice flow, raw juice flow, diffuser drum speed, beet slice weight, diffusion supply flow, temperature of pulp juice mixture, pulp mixer level, diffusion supply tank level, and flow of sludge. (See illustration overleaf.)

An automatic " Klaxon " alarm system covering all the important parts of the plant is centralised on the control panel and is associated with the usual push-button cancelling facility.

Continuous Diffuser.—The R.T. continuous diffuser at Wissington is a drum with an internal diameter of 5·4m (17ft 9in), made by Duncan Stewart and Co., Ltd., Glasgow, S.E. It is designed for a continuous throughput of 2400 tons of sliced beet in a twenty-four-hour day, and its function is to extract the sugar-bearing juice from the beet strips by bringing them into contact with hot water, whereupon the sugar diffuses into the water. To do this the beet strips or cossettes and water are fed into opposite ends of the drum and traversed in opposite directions while the drum is rotated at a controlled speed between 16 and 25 revolutions per hour.

The drum is divided into thirty-three transverse compartments and at the beet inlet end there is a 23ft diameter charging head which is attached to the drum and revolves with it.



The Evershed control panel at Wissington factory, where the process of sugar extraction from beet is controlled by a closed-loop system

A fixed head or casing encloses the charging head, and the overall length of drum and fixed head is 120ft. Internally the drum consists of a series of division plates welded to form a double-spiral path with a central longitudinal division plate, on each side of which there is a chute connecting the compartments. In each compartment there is a set of baskets made from perforated plate. Sliced beet cossettes are introduced at the head end of the drum and water at the other end, which is slightly higher to provide for gravity flow of the juice. As the drum rotates the " spirals " or inclined ducts move the cossettes through the juice and, once per revolution, the baskets raise the cossettes out of the juice and discharge them through the communicating chutes into the next compartment. This contra-flow movement is continuous ; the incoming cossettes, of high sugar content, are carried from one compartment to the next, meeting juice of progressively lower sugar content until, at the other end of the drum, the beet (by now nearly exhausted of sugar) meets the incoming hot water and is discharged from the drum. Flowing in the opposite direction the water absorbs sugar and, as it progresses by gravity to the other end of the drum and becomes more concentrated, it meets cossettes of progressively higher sugar content until it is discharged at the head end.

Besides the spiral division plates, the basket screens in each compartment are set at an advancing spiral so that over the full range of compartments there is a helix equal to one half revolution. This arrangement ensures a steady driving load (see illustration below).

The drum is of mild steel construction throughout and is supported on cast steel riding rings running on cast steel support rollers, the roller shafts being carried in roller bearings. The drum is fabricated in the workshops in eleven sections, and the sections are assembled and welded together on the site. The final driving gear spur wheel is cast integral with one of the riding rings, which simplifies gear alignment and concentricity.

A 65 h.p. motor running at 960 r.p.m. drives the diffuser drum and the variable speed is obtained through a fluid coupling, as described more fully below, the reduction ratio of 243·7/1 and a final reduction gear, the wheel having 268 teeth and the pinion thirty-one teeth, 1in diametral pitch, the wheel having an overall diameter of 22ft 6in. The weight of the revolving drum fully charged with juice and cossettes is 450 tons.

To give an impression of the completed R.T. diffuser we reproduce below a view of part of the installation at the Peterborough factory.

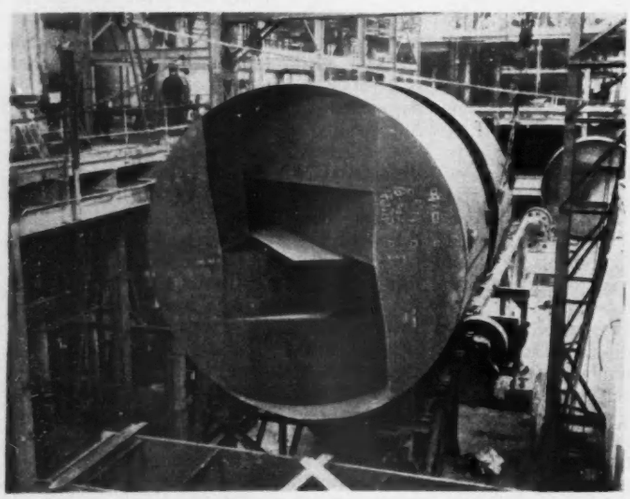
Control of Beet Weight.—Beet entering the factory via the washer is fed by hoppers to four horizontal-disc slicing machines, each of which is driven by a standard squirrel-cage motor equipped with Vulcan-Sinclair scoop-controlled fluid drives. The knives on the slicing machines are circular with a saw tooth profile radially, to cut the beet into strips or " cossettes." The saw tooth spacing of the cutters is chosen to produce the thinnest strips (presenting the maximum surface for diffusion) consistent with satisfactory operation of the subsequent filter presses, bearing in mind that the thinner slices tend to clog the presses.

From the slicing machines the beet strips are discharged on to a belt conveyor which is equipped with a Simon weigher. An Evershed position transmitter associated with the scale of this weigher gives a continuous record of beet strip weight. The signal from this transmitter has two functions—the first is to operate the weight controller as described below; the second is to operate a controller which determines the diffusion supply ratio.

The output signal of the weight controller (*WtRC* in schematic) is transmitted to four automatic/manual stations which control the slicing machine speeds by regulating the position of the scoops in the fluid couplings. Weight control of the beet on the conveyor is, therefore, on a closed loop system ; any departure from the preset weight is detected by the weigher and a signal proportional to the error is made to vary the speed of one of the slicing machines (and, therefore, its output) in such a way as to restore the weight of sliced beet to its preset value.

In normal operation three slicing machines are mincing (two on manual control, and one automatic), while the fourth machine is on standby duty. The running machines are set to keep the controller output at about 70 per cent full scale, and the output of the controller is limited so that any scoop under automatic control cannot fall below 50 per cent full scale. Accordingly, the slicer speed can never drop to zero and there is a provision whereby any failure of the controls causes the scoop to assume its maximum-power position.

Control of Drum Speed and Level in Circulating Tank.—As already indicated, the raw juice gravitates towards the head end of



(Left) Sections of the R.T. continuous diffuser during erection at Wissington factory. The frame for the basket separating the compartments can be seen (left centre), as can the sloped plates which form the spiral and the compartment-connecting chute. (Right) R.T. continuous diffuser at Peterborough sugar factory

the drum, having extracted sugar from the cossettes. There the juice collects in the circulating tank which is built into the fixed head of the drum—other systems have a separate circulating tank in association with the diffuser.

In this tank there is a diaphragm-operated level transmitter. It is adjusted so that when the raw juice rises from a predetermined upper limit the speed of the drum is reduced, as is the weight of beet entering the drum.

Control of the drum speed is exercised by a Vulcan-Sinclair fluid coupling as mentioned above. A tachometer is fitted to the high-speed shaft of the gearbox between the fluid coupling and the drum and it provides the measured value of a speed controller. The required value of this controller is automatically reduced when the juice level rises from the limit, whereupon the electrical output from the speed controller operates an air diaphragm servo-motor linked to the hydraulic scoop and thereby lowers the drum speed. At the same time a signal is transmitted to the weight controller to reduce the input of beet strips to the drum.

Diffusion Supply Control.—At one end of the drum the exhausted beet slices are discharged and carried by a screw conveyor to a pulp mingler. On this pulp mingler there is a diaphragm-actuated level controller to regulate the supply of fresh make-up water. This make-up water is acidified as determined by a pH controller made by Electronic Instruments, Ltd. The acid is introduced by a micro-spline dosing valve from an open supply tank. Acid dosage is pneumatically controlled but the electrical output of the pH controller is transmitted to the main control and recorded there. A level control on the mingler operates a Saunders valve on the make-up line.

From the mingler the pulp is pumped to a separator where water is extracted and returned to the mingler or diffusion supply tank. This diffusion supply tank is copper-lined and has a copper-float level transmitter which operates over a 10ft range and feeds a controller to regulate a valve in the line from the separator.

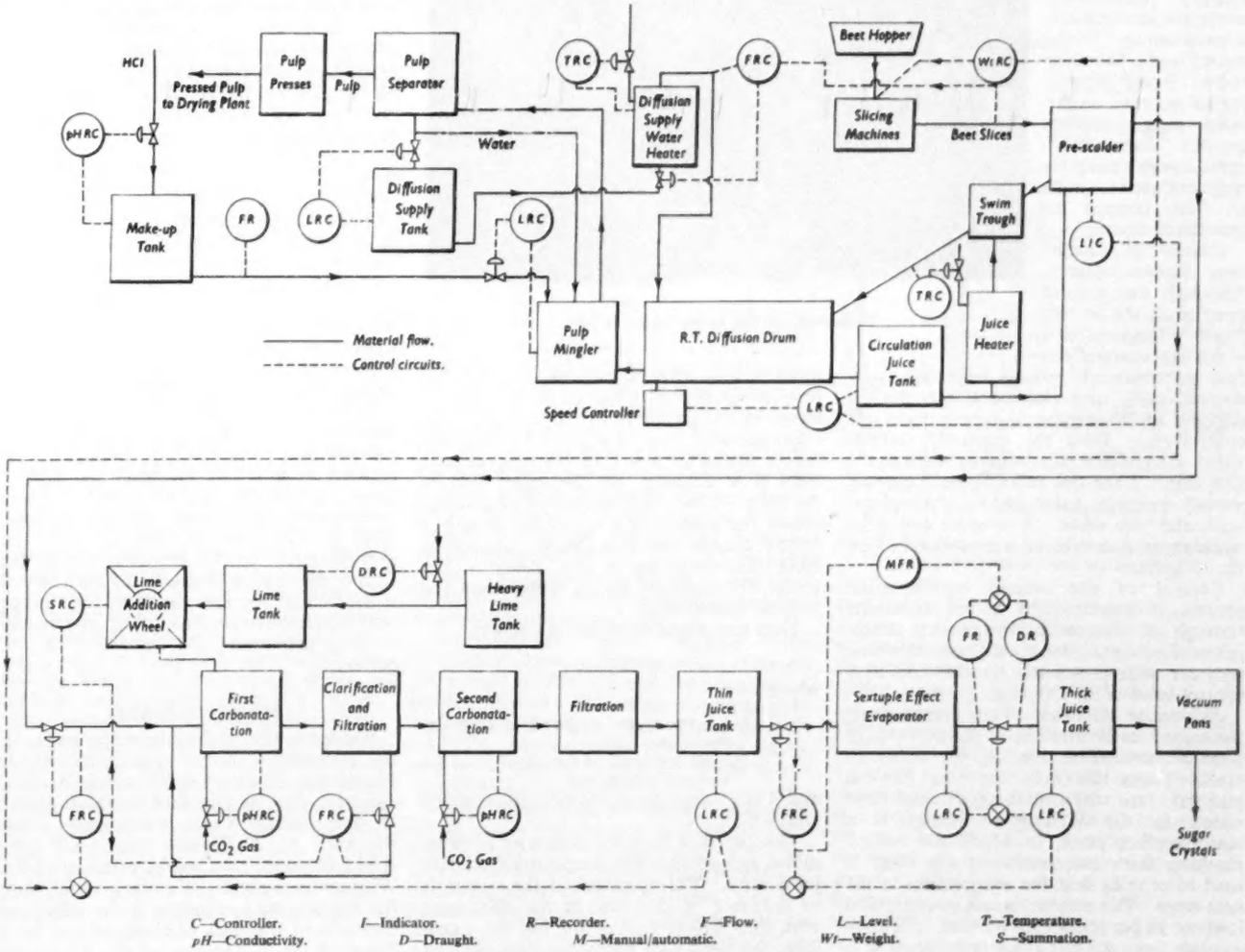
After passing through the separator the pulp is passed to presses. After a proportion of molasses has been added it is fed to an automatically controlled drying plant. Drying is done by forced circulation of air heated in a coal-fired furnace. Control of the drying process is effected by a closed-loop system in which the temperature of the air is measured after passing over the pulp. A deviation from the normal condition results in a change in temperature and a corresponding error signal is transmitted to a Metropolitan-Vickers electronic control panel which makes an appropriate adjustment to the speed of the motor driving the pulp feed. Thus the pulp feed to the drier is regulated to restore the predetermined drying conditions. The dried pulp is sold as cattle food, mainly as loose material in 1 cwt sacks, but at Wissington some of the pulp is sold as blocks made by compressing the stuff in a briquetting machine.

At the same time the water from the diffusion tank supply is pumped through an automatically-controlled heater to raise the temperature to a preset value (70–71 deg. Cent). The diffusion supply, like the fresh water make-up supply, is measured by a transmitting "Rotameter." The diffusion supply controller is ratio-controlled from the weight transmitter on the sliced beet conveyor. A knob on the main control panel is adjusted to give the desired relationship between the weight of beet and the diffusion supply. The ratio of these quantities is then maintained automatically, the diffusion supply is made to suit the slice input to the drum and this slice input, it will be recalled, is governed by the level in the circulating tank.

Control of Raw Juice Flow.—Some of the raw juice from the circulating tank is pumped through an automatically-controlled circulating juice heater into a swim trough where it meets beet strips, which have already been initially heated in a pre-scalder, and carries them to the rotating head of the drum. Before reaching the heater some of the juice is bled off to the pre-scalder from which the juice is pumped forward as raw juice for the subsequent process of carbonatation.

For the automatic control of the juice heater in the swim-trough loop the measured value of temperature is taken from a temperature transmitter in the line after the swim trough. The heater controller is a three-term instrument and its output controls the position of a butterfly valve in the steam line to the heater.

On the pre-scalder there is a diaphragm-operated level transmitter which provides the measured value for the raw-juice controller : matters are so arranged that if the pre-scalder



Block schematic diagram of controls at Wissington

level falls then the raw-juice flow is correspondingly reduced.

Raw-juice flow is measured by a transmitting "Rotameter" which operates a Kent "Multelec" instrument. An extra potentiometer is connected to the "Multelec" instrument so that a signal can be transmitted as a measured value to the flow controller. From another potentiometer a corresponding signal can be transmitted to the Lancashire Dynamo electronic speed controller that regulates the speed of the lime wheel. In this way the flow of milk of lime can be controlled to be accurately proportioned to the raw juice to which it is added. The density of the milk of lime is automatically controlled to a constant preset value and both the speed of the lime wheel and the density of the milk of lime are recorded on the main panel.

In the next series of processes—first and second carbonatation and filtration—the control loop is provided by the level of the product in the thin-juice tank operating on the raw-juice flow. If the level of liquid in the thin-juice tank rises to within 2ft of the top then a level transmitter operates the raw-juice controller and reduces the flow.

At the same time the raw-juice flow transmitter also sends a signal to the flow controller of the sludge returned from the Oliver filters to the raw juice. For this function use is made of a ratio control which is similar to that on the diffusion supply, described above, and incorporates a transmitting "Rotameter" and a Saunders valve. Sludge density is also recorded on the main panel, making use of a "Rotameter" densitometer similar to that developed for milk of lime control as mentioned above.

Control of Continuous Carbonatation.—Although the general practice in the British Sugar Corporation's works is to control the first carbonatation process by conductivity control using ring electrodes, the method adopted at Wissington is to use Kent pH controllers. Here the controller output varies the position of a butterfly valve in the CO_2 line. When this valve closes it opens a second butterfly valve in an atmospheric vent, and vice versa. A pressure controller working to atmosphere, is also installed on the CO_2 line.

Control of the second carbonatation process is exercised by a pH controller through an Electronic Instruments transmitter feeding a Honeywell potentiometric recorder with pneumatic transmission to a control valve in the CO_2 line.

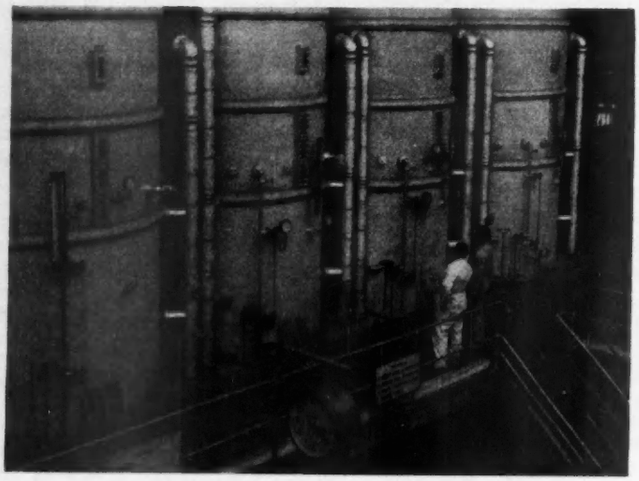
Evaporator Controls.—The output from the second carbonatation is passed through filter presses before entering the thin-juice tank. From this tank the thin juice is pumped into the multi-stage evaporator which, in the Wissington factory, is a sextuple-effect plant, in which the vapour resulting from evaporation at any stage is used to provide heat for evaporation in the next stage. The nominal steam consumption is about 29 per cent steam on beet. The concentrate from the last effect is collected in a thick-juice tank.

In the present stage of development on the Wissington plant the evaporator controls are based on regulation of the level in the sixth vessel, control of the input of thin juice and the output of thick juice and measurement of the density of the thick juice.

Considering the thin juice first: as mentioned above, if the liquid level rises to within 2ft of the top of the thin-juice tank a level controller is actuated to reduce the raw juice flow and, consequently, the throughput of the carbonation processes discharging into the thin-juice tank. Conversely if the thin-juice level falls to within 2ft of the bottom of this tank a controller comes into operation to reduce the flow of thin juice from the tank into the evaporator. This thin-juice flow is measured by an orifice plate and diaphragm transmitter. A level recorder fitted on the main panel is actuated by a stainless-steel-float level transmitter on the thin-juice tank.

In the evaporator itself control is exercised on the sixth vessel and just before the thick-juice pump. There is a displacer-type level transmitter associated with the balloon to give, for a 0–6ft change in level, a 30–0mA signal to a controller whose output feeds into a computer.

At the same time a diaphragm transmitter in the thick-juice tank transmits (in response to a change in level from 1ft to 6ft) a 30mA signal into a proportional controller. The required valve is set to a point 9in from the top of the range and then the proportional band is so adjusted that the upper 18in in the range of the thick-juice level transmitter causes the proportional controller to give a current change from 0 to 15mA. An output from this controller is also taken to the computer that is fed with a signal from the balloon transmitter.



Evaporators in the Felsted sugar factory

Then the output from this computer,

$$I = Al_1 + l_2$$

where

l_1 is proportional to the signal from the thick-juice tank.

l_2 is proportional to the signal from the balloon transmitter

and A is a factor that is variable between 0·1 and 1·0.

This output I from the computer is transmitted to a position which operates the thick-juice valve. The operation of the system is as follows: if the level in the thick-juice tank rises within 18in of the top the signal from the thick-juice controller increases and the thick-juice valve closes; the level in the balloon then rises, the output signal from its controller is reduced, which tends to open the valve. The opposing influences exerted by the outputs of the controller persist until the output from the balloon falls away to zero whereupon the output from the thick-juice tank assumes complete control.

Other Technical Developments

We have devoted some space to a description of the Wissington factory because it is the first installation anywhere with automatic control of raw sugar manufacture. Similar examples of technical progress are to be found in many of the other factories of the Corporation. Thus at Ely and Kidderminster diffusion batteries are to be replaced by Duncan Stewart continuous diffusion drums for the 1959–60 campaign. The drum at Ely will be fabricated on site and will be of 22ft 2in diameter by 116ft long, with a throughput capacity of 4500 tons per day. At Kidderminster the drum will be of 19ft diameter by 115ft long, designed for a throughput of 2800 tons per day. In both factories there will be automatic control of the extraction process only.

Further technical advances that are envisaged by the Corporation include continuous pressure filtration for the second carbonatation; this can be linked up with the continuous vacuum filtration for the first carbonatation. It is estimated that in the larger works this change alone would enable the number of men required for filtration to be reduced from fifteen to one per shift.

Another important technical improvement is in the production of milk of lime at standard density for the carbonatation. In the lime kiln at the Ipswich factory (illustrated on page 878) this production of milk of lime is a fully automatic process from the charging of the hoppers with weighed quantities of limestone and coke to the automatic discharge of burnt lime. This process has proved to be so successful at Ipswich that its use is to be extended to other factories.

The main incentives that are common to all these steps towards automation are, first, to reduce the demands on manpower and, secondly, to eliminate onerous tasks. It is not merely a question of trimming production costs but is rather a matter of minimising the difficulty of attracting labour in an industry which is essentially seasonal. The effects of progress in this direction since the war can perhaps be summarised in figures.

In the period from 1944 to 1957 the average labour content in each ton of beet processes, expressed in man-minutes per ton was reduced from 137 to 53, while the present figure for the Wissington factory is only thirty-seven man-minutes per ton of beet. Over the same period, 1944 to 1957, the average daily output capacity of all the Corporation's factories increased from 31,000 to 48,000 tons per day. Similarly the average coal consumption expressed as a "percentage on beet processed" fell from 10·5 to 7·2 per cent.

Acknowledgment

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Large Electricity Supply Systems

No. I

The seventeenth full convention of the International Conference on Large Electricity Systems (C.I.G.R.E.) is being held in Paris under the patronage of Monsieur René Coty, the President of the French Republic. The meetings, which are being attended by delegates from forty countries, began with an opening ceremony on Wednesday, June 4, and the last session will be held tomorrow, June 14. The subjects under discussion are : transformers, teletransmissions, generators, circuit breakers, capacitors, high-voltage cables, system stability and control of load and frequency, insulating oils and materials, insulation co-ordination, reactive and distorting phenomena, protection and relays, voltages over 220kV, lightning and surges, telephone and radio interference. In our opening article, below, we give a résumé of some of the papers on transformers discussed on June 5, and of some of the contributions to the discussion.

(110) *Trends in Large Transformers.*—Special problems and trends in large power transformers were examined in a paper (No. 110) by E. C. Wentz (Westinghouse Electric Corporation, U.S.A.). He discussed some of the means by which larger and more economical transformers were being produced, including : continued improvement in magnetic material ; reduction of insulation by improvements in system and arrester design ; better cooling, mainly by forced-oil-cooling directed through coil ducts ; a more uniform distribution of impulse voltage within the windings ; and more refined methods for accurate calculation of the impulse voltage at any point in the winding.

With regard to the latter point the author Wentz mentioned two general ways in which computers have been applied to transformer design. In the first a programme is devised, to use as input the rating constants of the transformer, together with certain design constants, such as flux and current density and ratio of iron to copper ; the result of this procedure is a single design with performance characteristics defined by the original choice of design constants. In the second system a more elaborate programme is arranged. The required performance is part of the input and the choice of design constants is made by a philosophy of design programmed into the computer ; corrective routines are added to change the choice of design constant. The design procedure is thus reiterated until the required performance characteristics are obtained. Such a programme, involving full instructions for each corrective routine, is very complex and requires the use of a large computer, such as the IBM 704 or 705 or the " Univac."

(111) *Insulation of High-Voltage Transformers.*—Some insulation aspects of large high-voltage transformers were discussed (in paper No. 111) by J. Meador (General Electric Company, U.S.A.), who observed that improvements in lightning arresters had made it necessary to re-evaluate switching surges, since in some cases lightning surges were no longer the determining factor in deciding transformer insulation levels. Further reductions in these levels were bringing operating voltages and test voltages closer together and more assurance was, therefore, required that the initial insulation strength would be maintained throughout the life of the transformer. Since switching surges frequently determined the limiting stress, Meador suggested that more attention should be devoted to phase-to-phase, rather than line-to-earth, voltages, and the standard values required between phases be reviewed.

He described a new system of oil preservation known as " Atmoseal," whereby a constant pressure could be maintained, eliminating difficulties resulting from supersaturation of the oil with gas, and the subsequent generation of bubbles which lowered the electrical strength of the oil by 20 to 60 per cent.

(120) *Transformers for the British 275kV System.*—Comparisons of designs of British 275kV transformers were made in paper No. 120 by W. Casson and G. B. Harper, of the Central Electricity Generating Board (Great Britain). They analysed the two kinds of 275kV windings—the disc coil and the multi-layer concentric winding. They concluded that, whilst the multi-layer design had inherent advantages with regard to voltage, the disc construction tended towards a more economic design : the differences were, however, marginal so that the choice was largely a matter of personal preference. Finally, the authors surveyed recent developments and examined their influence on present and future requirements.

Their conclusions can be summarised as follows. British electricity supply authorities favour three-phase transformers as compared with banks of single-phase units and the demand for very large transformers raises difficult transport problems ; with present practice, taking advantage of the weight reduction associated with cold-reduced, grain-oriented steel, 210MVA represents about the limit of weight and size. But better application of this core material will be possible when it is available, in the near future, in continuous strip form instead of in sheet, as at present. Refinements in core design with the aim of optimum utilisation of core material, possibly with higher working flux densities, should result in increased ratings for a given weight. Gains are also possible in tank design, for example, by choosing contour construction and thus reducing the weight of external stiffening. Marginal weight reductions are being made in clamping structures for cores and coils.

Manufacturers have inquiries for 275/132kV auto-transformers with a throughput rating of 180MVA and, with the use of cold-reduced steel, the weight should be only slightly greater than that of the present 120MVA transformer. Auto-transformers with a throughput rating of 240MVA are envisaged for the future.

Present commitments include provision for generator transformers of 310MVA and 620MVA for use, respectively, with the 275MW single-shaft generators and 550MW cross-compound sets now on order. For the 310MVA transformer, one proposal that is being studied is to omit regulating windings from the transformer and to provide the required voltage adjustment by a separate booster. For the 550MW set possible alternatives are either banked three-phase transformers or single-phase transformers to form a 620MVA bank.

Although there is no economic justification for transmission at 380kV in the near future, it will be recalled that certain sections of the British supergrid are designed for conversion to 380kV working if required. Some development and design work has been done in anticipation of such requirements, and prototype tests on sample transformer windings have indicated that suitable designs are available for the insulation levels foreseen, namely, an impulse level of 1425kVp associated with a power-frequency test voltage of 630kV, r.m.s.

(104) *A Transductor On-Load Tap-Changer.*—In a paper (No. 104) on " A New On-Load Tap-Changer for Power Transformers on the Transductor Principle," A. Lang (A.E.G., Germany) discussed the possibilities of the transductor, magnetic amplifier (or d.c. biased reactor) as the basis of a contactless on-load tap-changer for power transformers. Despite the reliability of the established tap-changers with resistance transition switching the author concluded that a static system of automatic voltage regulation, exploiting the properties of the transductor, and, in particular, of ferromagnetic cores and semiconductor rectifiers, was worth investigation.

A schematic diagram of a transformer equipped with a transductor tap-changer is given in Fig. 1.

A fine regulating winding carrying nine

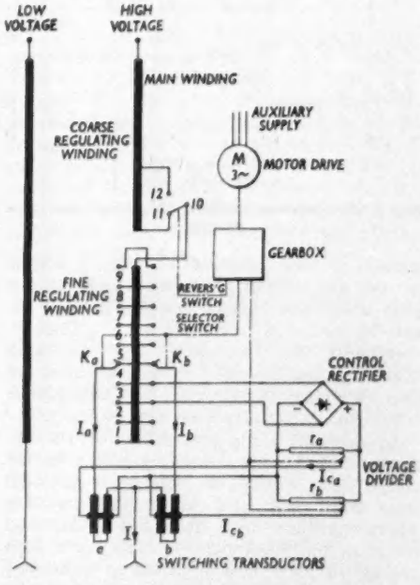


Fig. 1—Schematic diagram of a power transformer with transductor on-load tap-changing

taps in conjunction with a coarse regulating winding and its associated reversing switch allows for transformer regulation extending over ± 9 steps. Current is tapped via the sliding contacts K_a and K_b, both of which are connected to the same tapped winding. The load current (I) then divides equally between the fully d.c. saturated reactors *a* and *b* (that is, $I_a = I_b$). The saturating or control currents of these transductors are supplied by a control rectifier taking its a.c. input from the transformer which is being regulated. An ohmic or inductive voltage divider r_a, r_b serves to adjust the control current for the transductor *a*, *b*. A motor drive operates the tapping preselector, the reversing switch contacts and the voltage divider that determines the d.c. control of the transductors.

Operation of an on-load change between

taps 1 and 2 is shown in Fig. 2. The selector switch effects this change without any interruption of current, as follows. First, the transductor *a* is de-energised to carry only the no-load current of an unsaturated a.c. transductor of high inductive reactance; the contact K_a can then be moved from tap 1 to tap 2 without sparking (position I). In the meantime, the fully excited transductor (*b*) carries the rated transformer current ($I_b=I$). The second stage (position II) is commutation, with simultaneous excitation of transductor (*a*) and d.c. energisation of transductor (*b*), which causes the current *I* to switch from tapping 1 to 2. After com-

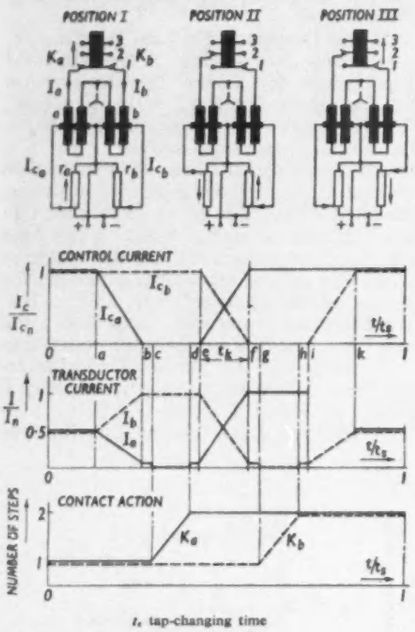


Fig. 2—Performance diagrams of a transductor tap-changer

pletion of this commutation step in a time t_k, the de-energised transductor (*b*) carries only a no-load current and the contact K_b can be moved to 2 (diagram 3). Then by re-exciting the transductor (*b*) the load current is again equally divided between the two switching transductors, and the cycle is completed in the step-switching period t_c.

In his paper Lang gave details of a transductor tap-changer consisting of d.c.-biased choke coils wound on high-grade toroidal strip coils, and used in conjunction with silicon rectifiers. An equipment of this kind designed for 100A current rating at a step voltage of 210V was subjected to endurance tests of 100,000 on-load tap-changes per contact. No noticeable wear of selector contacts was reported. The full advantage of the reduced wear would accrue if automatic voltage control were applied to the power transformer, in which case the operating demand on the equipment would tend to be high. The author suggested that a full-scale study should be made of the economics of his proposed system.

Discussion

Introducing the session on Transformers, Mr. E. T. Norris (Great Britain), the chairman, suggested that the discussion should be conducted under three main headings, namely, trends in large and high-voltage transformers; short circuits and their effects; and automatic control and on-load tap-changing.

Professor Dr.-Ing. W. Schäfer (A.E.G., Germany), who opened the discussion, advocated the need for retesting very large transformers (including impulse testing) after reassembly on site. The difficulties and cost of carrying out such tests raised the question of whether it was more economical to build very large transformers as single units or as banks of smaller units. Taking all costs into account, including dismantling, reassembly and retesting it was likely that an output of, say, 600MW could be achieved as cheaply from a subdivision into smaller units, with the added advantage that in the event of a fault on one " sub-unit " the service interruption would not be complete. There were strong arguments, therefore, for limiting the unit size of large transformers.

Mr. G. B. Harper (Central Electricity Generating Board, Great Britain) suggested that a cost comparison of a single large unit with a number of small units to give the same net output would probably favour the former if account were taken of all relevant factors, including substation buildings. Besides, he questioned the necessity of repeating impulse tests after erection on site, although it would be desirable to monitor the condition of insulation on site and compare the results with works test figures.

Mr. B. Sollergren (A.S.E.A., Sweden) agreed with Mr. Harper that impulse testing would be too complicated and expensive to carry out on site.

Mr. F. C. Walmsley (Micanite and Insulators Company, Ltd., Great Britain) discussed some aspects of high-voltage bushing design* and declared that oil-impregnated-paper bushings could be made to the same dimensions as those of solid porcelain bushings. The re-entrant bushing developed in Great Britain had been made for voltages up to 380kV; compared with porcelain bushings, there was a considerable reduction in length and the small increase in the diameter carried no disadvantages. If spiral lapping was used, there was no serious difficulty in the manufacture of very long re-entrant bushings. Mr. Walmsley illustrated his remarks with slides showing cross-sections of typical bushings, including a double re-entrant bushing for cable joints.

Mr. A. T. Chadwick (English Electric Company, Ltd., Great Britain) referred to the topic of sealed tanks with a cushion of nitrogen, and confirmed the mechanism given in paper No. 111, whereby gas bubbles could be formed on the surface of the insulation when the oil stirred by the circulation pumps was supersaturated. He suggested that electric stress was at least as important as vibration as a factor favouring the production of bubbles in supersaturated oil. He showed slides illustrating the generation of bubbles in a test rig of supersaturated oil under electric stress when the pressure was reduced from 7 lb to ½ lb per square inch.

Mr. E. T. Norris (Great Britain) contributed to the discussion by putting forward the idea of assessing the strength of a transformer winding in terms of the tensile strength of copper. He thought that there had been no occasion in engineering practice to build up knowledge about the precise behaviour of copper when subjected to very small strains such as those involved in transformer windings subjected to repeated short circuits. There was, for example, room for much more accurate knowledge than was at present available about the cold-working properties of copper. The cold-working to which copper was subjected in transformer windings depended to a large extent on the impurities present in the copper, whereas one of the aims of copper manufacturers seemed to be the production of greater purity and lower resistance. The whole subject of impurities and their effect on the cold working properties of copper, therefore, offered a very fruitful field for research.

Mr. W. Casson (C.E.G.B., Great Britain) referred to auto-reclosing and fault-throwing tests on through faults on the British 275kV system. With the high impedances characteristic of the transformers on the system (say, 20 per cent on a double-wound unit), the maximum fault current on such tests would be five times full load current and repeated short circuits of that order had been withstood. Under the circumstances, the chances of the fault duration exceeding 0·5 second were small. Mr. Casson referred to the recent introduction, in Great Britain, of recording oscillographs to record fault current. He suggested that it might be worth while to develop a high-set over-current relay designed to operate at one of a given number of multiples (such as five or ten times) of full load current.

Mr. F. W. Gee (Ferranti, Ltd., Great Britain) dealt with some aspects of the mechanical design of winding insulation, and he referred briefly to a transformer which his company was building with the object of finding some of the answers to problems on pre-shrinkage. In this transformer the weight of the windings was supported from the ground, while the weight of the core was transmitted via the top of the coil stack (which was thus placed in compression). With this arrangement the movement of any fixed point on the core would be a measure of the shrinkage of the coil-stack insulation. A simple system for providing a 4 : 1 magnification enabled the shrinkage to be observed and measured directly.

(*To be continued*)

* C.I.G.R.E. Paper No. 126, by H. Kappeler (Micafil S.A., Switzerland) described recent forms of execution of 380kV transformer bushings.

Technical Report

The Effect on Weather Minima of Approach Speed, Cockpit Cut-Off Angle and Type of Approach Coupler for a Given Landing Success Rate and Level of Safety. E. S. Calvert, B.Sc., A.R.C.Sc.I., and J. W. Sparke, B.Sc. A.R.C. Current Paper No. 378. H.M. Stationery Office. Price 3s. 6d.—The performance of instrument approach aids has hitherto been assessed in two ways. The first way is to determine the mean and maximum deviations from an ideal path. This is of little use. The second way is to determine the lowest height down to which the approach aid can be used and still allow sufficient time for the pilot to see the ground and make corrective manœuvres if necessary. This is more useful to the operator, but to apply it, assumptions have to be made as to the final corrective manœuvres which the pilot is willing and able to make under visual guidance in bad visibility. In the past the assumptions made have been arbitrary.

During 1955–56, full-scale flight tests have determined the times actually taken to correct azimuth displacements of various magnitudes, and it now seems that these final manœuvres are closely related to the human characteristics of the pilot. During the same period, operational research and simulated tests have determined the minimum visual stimulus which must exist if the pilot is to make these manœuvres with an acceptable level of safety. This note uses these results to show the effect on visual range and cloud base of approach speed, accuracy of instrument aid, cockpit cut-off angle, width of runway, and length of approach lighting pattern, for a given landing success rate.

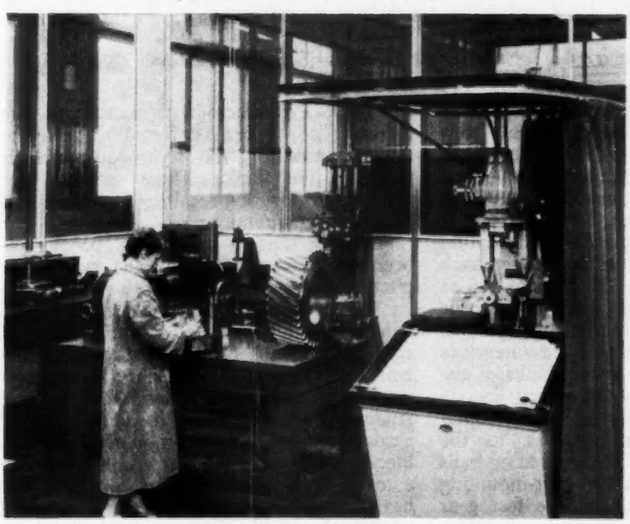
It is pointed out that with a ground pattern which includes crossbars the visual information becomes adequate in the horizontal plane at a greater height than it does in the vertical plane. There are theoretical reasons for thinking that in marginal weather conditions, no improvements in the ground pattern will ever raise the quality of the guidance in the vertical plane to that which exists in the horizontal plane. The implications of this are widespread, and have a bearing on a number of factors. These factors are discussed, particularly in relation to future aircraft, and some suggestions for improving safety are made.

Open Days at M.E.R.L.

No. I.

This year's open days at the Mechanical Engineering Research Laboratory, near Glasgow, were held on June 4 and 5. Two new buildings, completed last year, house the Metrology and Heat projects, and the laboratories for the former are thought to be among the finest in the world. A DEUCE computer has just been installed, in the first instance mainly for the preparation of thermodynamic tables. We give below a brief account of some of the interesting work that is going on.

OPEN days at the Mechanical Engineering Research Laboratory were held on June 4 and 5. Visitors observed that two new buildings had been completed, one of them devoted to metrology and the other to heat transfer and thermodynamics. The latter building is intended also for some of the work on plasticity, and is not yet fully in use. In describing the metrology laboratories to some of his visitors, Dr. D. G. Sopwith, the director of M.E.R.L., stated that these are among the finest in the world. All external windows are double-glazed and fitted with venetian blinds, and the test rooms are surrounded by a corridor of which the temperature is regulated. Each test room is supplied with air at a temperature of 68 ± ¼ deg. Fah. This, having been conditioned by automatically controlled refrigerating and heating plant, arrives through a system of ducts concealed in a false ceiling. Floors of polished hardwood blocks help to keep dust to a minimum. The standards room has a thick concrete base resting on a rubber mat, being thus insulated against vibration. The metrology section serves industry and Government departments as well as conducting original research. The service covers such tasks as the measurement of surface finish and the certification of gear hobbing machines of up to 20ft diametral capacity.



Part of the temperature-controlled wing of the metrology building

The Heat Division's new laboratory includes large experimental bays (the "Heavy" bay is 108ft by 50ft and has a basement 8ft deep). A DEUCE digital computer has just been installed. In the first instance this will be used mainly in the preparation of thermodynamic tables. Computation of the properties of a single substance, which would ordinarily take about two years, requires only a month on DEUCE. As well as converting experimental data into tables of the thermodynamic and transport properties of fluids, the computer will be used to process data from a number of test rigs, the latter in some cases being arranged so that punched tape records are produced ready for feeding to the machine. Partial differential equations in heat flow and fluid dynamics (including lubrication) will also be solved.

The services available throughout the Heat building may be summarised thus :

Steam.—750 lb per square inch at 750 deg. Fah.: 3000 lb per hour, i.e. about 4,000,000 B.Th.U. per hour or 1170kW. 100 lb per square inch saturated : up to 22,000 lb per hour, i.e. about 25,000,000 B.Th.U. per hour, or 7300kW. From this latter supply, 10,000 lb per hour can be superheated to 750 deg. Fah., and 10,000 lb per hour can be supplied at a reduced pressure of 15 lb per square inch.

Water.—Since the supply of mains water on the site is limited, a storage tank of 108,000 gallons capacity has been provided. In addition, there are two cooling towers with a capacity of 77,000 gallons per hour of water cooled from 90 deg. to 77 deg. Fah., i.e. about 10,000,000 B.Th.U. per hour or 2930kW. Provision has been made for installing constant head tanks in various parts of the building.

Electric.—A total of 1750kVA is available for experiments. 1000kVA is provided by a variable-voltage system and 300kW of the remainder is available as direct current. The voltage of every supply is stabilised to within about ±½ per cent. There are five units in the variable-voltage system, each rated at 200kVA (415V, three-phase, 50 c/s). The voltage from each can be controlled independently, the voltage between two phases being regulated to within ±½ per cent at any point between 60V and 440V. Two or more units can be connected in parallel to loads of up to 1000kVA. The units are remotely controlled from desks alongside the experimental apparatus.

Metrology, Instrumentation and Control

Lead Measurement on Marine Pinions.—Hitherto the lead of large marine pinions has been measured by portable axial-pitch gauges using ball styles. These instruments measure over several pitches of total length about 6in. The new machine at M.E.R.L. is designed to measure the helix continuously over its length.

The gear under test is normally measured relative to the journals on which it rotates, and roller rests are provided which are adjustable in two directions in order to align the gear axis in relation to the machine main-spindle axis. The rests are mounted on a scraped bed (running the length of the machine) which provides the datum. The measuring carriage, which is mounted on balls running in precise vee-ways, traverses parallel to the gear axis and carries a side-acting electrical gauging head which registers on each flank of one gear tooth in turn. The measuring carriage is connected by a link to a roller assembly, which bears on a sine arm attached to a transverse carriage. The latter rotates the main spindle by means of precise steel tapes, the main spindle itself being mounted in selected roller bearings. The sine bar is set to the required angle by means of slip gauges, so that the nominal angular rotation of the gear under test, coupled to the machine's main spindle, is correctly related to the linear movement of the measuring carriage. The measuring carriage is motor driven through an infinitely

variable drive, so that, after setting up, a continuous autographic record is obtained from the side-acting electrical gauging head. In addition, direct linear-pitch measurements may be made.

The diametral and length capacity of the machine is about 20in and 70in, the overall base dimensions being about 11ft by 3ft. In view of the relatively large diametral capacity, the angular rotation of the main spindle must be correct in relation to movement of the measuring slide to a high order of accuracy. It is anticipated that calibration of the effective diameter of the main spindle and steel tape, now being carried out, will result in rotational accuracy of two to three seconds of arc.

Master Screw Correcting Lathe.—This lathe was built in 1904 by Sir W. G. Armstrong Whitworth and Co., Ltd., and installed in the Metrology Division of N.P.L. It has been transferred to the Mechanical Engineering Research Laboratory during the last year, and in due course will be available to continue the service formerly available at the N.P.L. in the correction of high-grade lead screws, e.g. for gear-hobbing machines and other precise applications. When originally manufactured the lathe screw was only 3ft long, but considerable modifications were made in the early 1930s so that screws up to 10ft in length may now be corrected. The lathe traverse itself is 5ft, and threaded lengths up to 10ft are corrected in two portions, by reversal. The modifications at that time also included the provision of a range of change gears, so that instead of correction only of $\frac{1}{2}$in pitch screws, the following may now be dealt with :

Threads per inch ...	2, 3, 4, 5, 6, 8, 10, 12, 15, 16, 20 and 25
Fractional pitches ...	$\frac{1}{2}$in, $\frac{1}{3}$in, $\frac{1}{4}$in, $\frac{5}{16}$in, and $\frac{1}{8}$in
Millimetres	15, 10, 5, $2\frac{1}{2}$, 2 and 1

When setting up for correction, the threaded portion of the screw is carried in half-bushes which rest in a long support on the bed of the lathe. This method reduces any tendency to bending during threading, but is dependent on the accuracy of the major diameter of the screw. Only screws which are sufficiently rigid to withstand the tendency to bend or twist are accepted for correction.

After correction on the standard lathe, screws are usually found to be accurate in pitch at the standard temperature of 20 deg. Cent., to within the following limits :

		Maximum departure from the true pitch between any two points on the screw
Excluding junction of two threads (if any)	Over any foot length	0·0002in
	Over any length between 3ft and 5ft	0·0005in
Including junction ...	Over any foot length	0·0003in
	Over any length between 3ft and 5ft	0·0007in
	Over any length above 5ft and up to 7ft	0·0010in
	Over any length above 7ft and up to 10ft	0·0015in

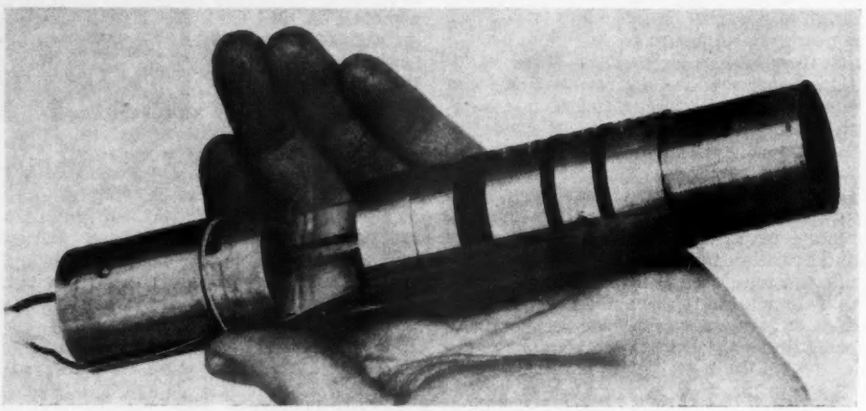
Precise Gear-Mesh Testing.—Many servo-mechanisms need fine-pitch gears with minimal backlash. Dimensional errors in such gears may be difficult to measure because of the relatively large size of the stylus. Errors in the spacing of teeth on a diametral pitch of 100, and departures from involute profile in teeth on a diametral pitch of 64, have been measured in the laboratory, but the apparatus is too elaborate for inspection under industrial conditions. In factories some form of rolling test is used in which the gear is meshed with a master of known accuracy. The dual-flank gear-mesh testing machine is often used, but the information from it is limited. It will show gear eccentricity but not indexing errors. An error of tooth contact frequency may be revealed, but it will not be clear whether this is due to errors in tooth spacing or in tooth shape. The major disadvantage of the machine is that it does not show the overall effect of the errors on the uniformity of motion transmitted.

To overcome this defect, a prototype gear-measuring instrument was designed in Germany shortly after the war under a research contract. In this device the teeth of the gears mesh on one flank only. Basically the machine works as a sun-and-planet system in which, by reference to a master gear having very small errors, transmission errors due to the gear under test produce small movements of the sun gear. The oscillations are detected by an inductive pick-up and recorded automatically. This machine has a disadvantage : very accurate master gears take a long time to make and are costly. A machine has therefore been designed in the laboratory round a precise gear rack which should be easier to make. The latest machine has a base about 17in long, on which are horizontal guide faces for a main carriage which can be made to traverse the length of the machine by a lead screw driven by an electric motor. Parallel to the direction of the carriage traverse is a vertical face of the base casting on which is a datum straight-edge 16in long. A carriage is mounted on ball bearings above the datum straight-edge ; it carries the master rack which is also 16in long. The carriage can be locked, or springs can be fitted to bias the master rack carriage in a direction parallel to the main carriage, so that measurements may be made on either set of flanks of the test gear. The gear-mounting carriage is carried on the main carriage, in horizontal precise vee-ways at right-angles to the direction of traverse, and is mounted on balls to reduce friction. On the gear-mounting carriage are centres to hold the test gear mandrel vertical. The test gear can therefore rotate horizontally while in mesh with the master rack.

For single-flank tests, a disc of the same diameter as the gear reference circle is mounted on the mandrel concentrically with the test gear and clamped to the gear ; it bears against the reference straight-edge, and the gear-mounting carriage is spring-loaded to ensure that the two remain in good contact. The master rack carriage is free to move, and is biased by the springs to suit the flank to be tested. As the main carriage traverses the length of the machine, errors in the teeth of the test gear cause the rack to move backwards and forwards in the direction of the traverse. Its movement is detected by an inductive pick-up and recorded automatically. For dual flank tests the reference disc is removed and the master rack carriage is locked. The straight-edge then serves as a reference for an inductive pick-up fixed to the gear-mounting carriage. The spring-loading of this carriage ensures full meshing between gear and rack ; any error is shown up as a movement of the carriage in a direction normal to the traverse of the master rack, and is automatically recorded as before.

Results obtained from the new machine are being compared with those from the earlier prototype single-flank machine and with those from a conventional dual-flank tester. The relation between the results is being analysed. The effect of errors in tooth accuracy on the uniformity of motion transmitted by a gear pair is also being investigated.

Measurement of Pitch Errors in Precise Lead Screws.—In conventional methods of measuring these errors, the screw is placed on a bench on which runs a carriage fitted with a fiducial indicator and a line standard. The positions of successive flanks are then determined by observing the line standard through a fixed micrometer microscope, the carriage having been adjusted to zero the fiducial indicator, the stylus of which is touching the flank. These methods are tedious and lengthy, resulting in fatigue and inaccurate observations.



Device for carrying out torsion tests inside a high-pressure container

An experimental measuring bench has been constructed in which the cumulative pitch errors are measured with reference to an N.P.L. diffraction grating using a moiré fringe technique. The operation of the equipment is entirely automatic, the errors being recorded on a linear chart. The equipment consists of a 6ft girder whose top and guide faces are scraped to fine limits of accuracy. On this are mounted two vee blocks which carry the screw under test and a carriage which runs on air-lubricated bearings—these giving the carriage a better straight-line motion than is obtainable with other types of bearing. The carriage is traversed along the girder by a screw which is driven through a gearbox by a variable speed motor. Connected to this screw is another gear train driving a cam which closes a micro-switch every time the carriage has traversed the nominal pitch of the screw under test. Fixed to the carriage is a small pneumatically-operated cross-slide carrying an inductive gauging head. During the measuring cycle this is brought forward so that the stylus touches the flank of the thread. The carriage also carries a 10in

length of 1000 lines-per-inch grating; the associated reference grating, lamp, optical system and photo-cell are fixed to the girder.

The carriage is traversed quickly between measuring cycles. These are initiated by closure of the cam-operated micro-switch, and the carriage slows down to a speed of about 0·001in per second; the stylus of the gauging head is moved forward to touch the flank and the recorder chart is inched forward. The carriage, traversing slowly, moves the stylus of the gauge head with respect to the body, and thus causes the pen of the associated recorder to sweep across the chart. At the same time, the output signal from the grating system is formed into a train of pulses which occur at intervals of 0·001in—the pitch of the grating. These pulses are fed to the pen of the recorder and cause it to mark short dashes on "Teledeltos" chart. The resulting record gives a measure of the position of the flank in relation to the position of the lines on the grating, interpolation between the grating lines being possible on the chart to an accuracy determined by the linear magnification. When this process is repeated on successive flanks, corresponding dashes on the chart can be joined up to give a pitch-error curve. There can be doubt as to which dashes on the record correspond to which lines on the grating, when the adjacent pitch errors on the screw are comparable with half the pitch of the grating. However, screws finished in corrector lathes of known accuracy seldom, if ever, show errors of this magnitude.

Precise Circular Scales.—One of the methods for automatic control of machine tools, and latterly of measuring machines, uses moiré fringes, produced from linear diffraction gratings of fine pitch ranging down to 5000 lines per inch. Extension of the technique to automatic angular control has led to a need for circular scales having a number of lines far exceeding the normal division in optical instruments.

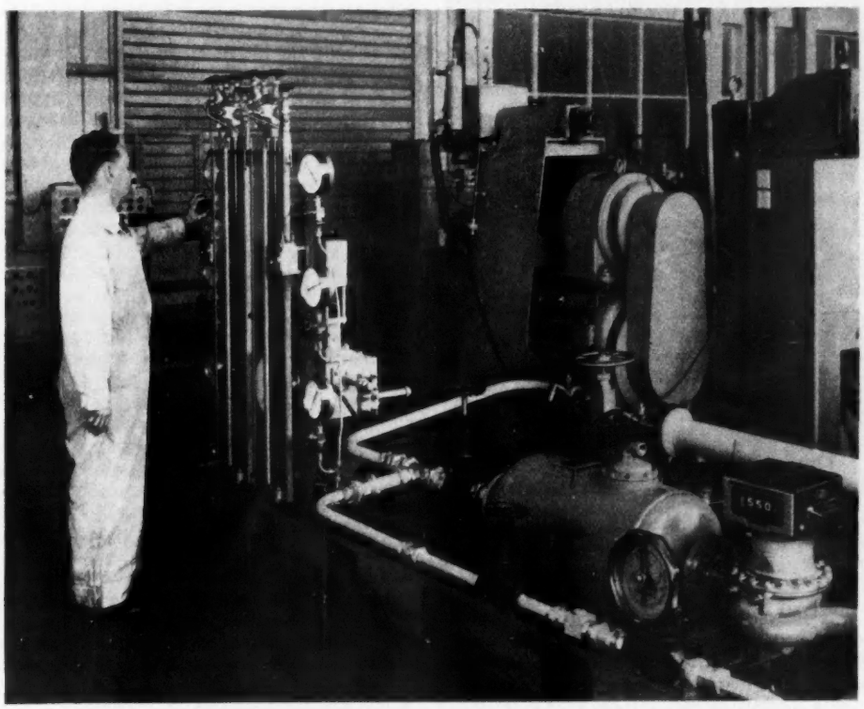
The machine installed at the laboratory is capable of ruling scales of a very high order of accuracy, namely, ±1 second of arc. The main table, of diameter 3ft approximately, is driven by a 720-tooth worm wheel at its perimeter, and a ground steel worm. Beneath the table and close to the outer edge is a continuous cam which, by means of an intermediate lever, serves to advance or retard the worm in order to eliminate as far as possible any cumulative errors in the pitch of the master worm-wheel teeth. Of equal importance to the final accuracy is the precision of the central table bearing, which on this machine is of taper-roller form. From tests made during the course of scribing reference circles on completed scales, the central bearing is thought probably to be true to about 0·000 02in. The machine functions automatically, the required ruling division being made through ratchet wheels attached to the main driving worm shaft, combined with a pawl mechanism. Various scales ranging from 1000 to 64,800 lines have been ruled, being cut by diamond in aluminised film on glass. In the application to moiré fringe techniques, it is desirable that the line width should be approximately half pitch, and the latter scale above was therefore cut with a line width of 0·0002in, the spacing of the lines being about 0·0005in and the scale diameter 10in. In order to conserve the tool during the cutting of so many lines, it was necessary to reduce the speed of the machine to the minimum, particularly with respect to the lowering of the diamond tracelet mechanism on to the glass for each line. The time required to complete the scale was about three weeks.

Duplication of these scales after ruling has been by producing contact prints on fine grain photographic plates. Special precautions are necessary to ensure that no movement of the emulsion takes place during the actual processing. Work is in hand to establish the stability of the emulsion over a period of time.

Control of Noise from Ball Bearings.—Noise from ball bearings is a problem in many industries, particularly in those producing appliances for domestic and medical purposes. Information is non-existent, even on important basic matters such as the relative importance of component accuracy and mounting conditions in determining the bearing's performance. A rig has been developed to allow the noise of ball bearings to be examined, and its dependence upon operating conditions and bearing parameters to be determined. Radial load, axial load and speed are the external factors which may be varied, and the ball bearings used have detachable plastic cages to allow ready variation of the components. A bearing size has been selected in which the balls may be assembled without deformation or springing of the races. This allows the tracks to be measured before and after assembly with the shaft and housing, so that the effect of mounting conditions may be deduced. The test rig has been designed so that the ball bearing noise will predominate, even with examples of the highest performance. The rig is installed in an anechoic chamber (see title illustration), while the driving motor and lubrication system are in an adjoining room.

The preliminary work has shown that the test rig is suitable for examination of the noise of the bearings in the frequency range above 800 c/s and that this is the frequency range containing the important part of the generated noise. The results obtained are repeatable, the variation observed on fitting a single bearing for a number of tests being less than that between a similar number of different bearings each fitted for a single test. Speed is found to be of primary importance in determining the generated noise, while the effect of both radial and axial load is not significant.

Before going on to investigate the influence of ball bearing accuracy in detail, the difference between commercial bearings and precise bearings of the same nominal size has been examined. It has been found that there is a large difference between the noise of the two grades of bearing, but that the response to speed and load is similar. Work is proceeding on the effect of diametric clearance on the noise of commercial bearings.



Measuring the head loss characteristics of oil-hydraulic fittings

Heat Transfer and Applied Thermodynamics

An important part of the programme of the Heat Division is concerned with experimental work, including the determination of physical properties, investigation of the basic processes of heat transfer, and analysis of the performance of conventional and novel heat-exchange equipment under near-industrial conditions.

The Heat building comprises a block chiefly of two storeys, called the Physics block, having laboratories on the ground floor and offices above; two halls for larger apparatus, known as the Intermediate and Heavy bays, which are contiguous with the Physics block, and a separate structure which houses transformers, superheater, pumps and so on, and was not originally intended to be used as experimental space; and a group of cooling towers.

Measurement of Viscosity of Gases.—Viscosity is one of the physical properties of a fluid required for heat-transfer calculations over a range of pressures and temperatures covering conditions in engineering plant. The collection of existing data on the viscosity of gases, in Heat Division, M.E.R.L., has revealed gaps in the ranges covered, particularly for the combination of high temperature and high pressure. Further, most of the high-pressure data have been obtained by the capillary method, and it seems desirable to confirm these by another method if one is available.

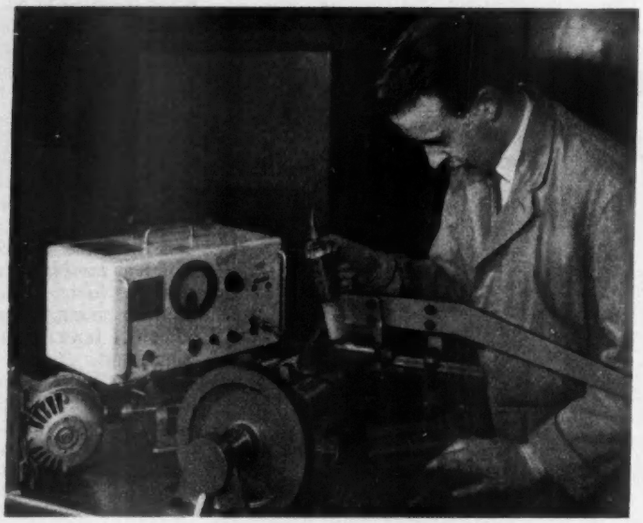
The "oscillating disc" method is being used, in which a small quartz disc, suspended horizontally from a wire attached to its centre, is set to oscillate in the gas; the rate at which the oscillations die away is used to determine the viscosity. This method has been in use for almost a hundred years, but until recently it was necessary to calibrate the apparatus with a gas of known viscosity and to confine the determinations to conditions similar to those used in the calibration. When a single calibration was used for experiments over a wide range of conditions the precision of the calculated viscosity was less than that of the original readings.

Theoretical work by Kestin and others on the nature of the fluid flow around an oscillating body of revolution has shown that the relationship between the viscosity of the fluid and the rate of damping of the oscillation is more complex than it seemed formerly. Recalculation of some experimental results using the new formula has shown greatly improved agreement with results from other methods of measurement.

An apparatus of this type, previously used at the Imperial College of Science and Technology, is now on loan to M.E.R.L., and will be used to obtain further confirmation of the theoretical conclusions. For example, it is intended to make measurements with discs of different dimensions. In order subsequently to make measurements at high temperatures as well as pressures, it may well be necessary to redesign the apparatus. The results and experience obtained with the present equipment will be needed for this purpose.

Heat Transfer to Mercury.—Liquid metals offer advantages for the cooling of certain nuclear reactors, and forced convective heat transfer in turbulent flow through pipes is being studied experimentally at M.E.R.L. The practical work is being limited to mercury and it is not thought that experiment on another metal will be needed; the results will be expressed in terms of the well-known non-dimensional numbers, and it is expected that they will apply quite generally. Mercury has obvious advantages in the laboratory but is not likely to be used in any nuclear reactor; for the latter, sodium and potassium are (at least in alloyed form) the most likely candidates. The main difference between liquid metals and other fluids that transfer heat is that thermal conduction plays an important part, and cannot be neglected in comparison with convection. The investigation will be devoted mainly to measuring the distributions of velocity and temperature across the sections of pipe.

In theoretical work on forced convection, assumptions have to be made, particularly regarding the velocity and temperature across the pipe or channel in which the fluid is flowing. This information is normally given in terms of the velocity profile (based on accurate measurements with water) and of the ratio of the eddy diffusivity of heat to that of momentum; this ratio, denoted by α, relates the gradients of the temperature and velocity profiles at any point. The velocity profile and the ratio α are known with sufficient accuracy for normal fluids; analytical predictions of heat transfer based on these data agree reasonably with measurements. It is realised that the high conductivity of liquid metals causes the temperature profile, and hence the value of α, to be changed significantly, the profile becoming more triangular. In analytical work on liquid metals, it has been assumed that the velocity profile remains unchanged and that the ratio α is constant (unity). The resulting heat transfer predictions are, however, higher than the vast majority of experimental results. The correct value of α can be found only by measurement of the velocity and temperature profiles. The value is not constant for all conditions; it varies with the fluid flow rate and possibly with other factors.



Radioactive tracers on a crossed-cylinders machine for studying wear processes

It is planned to make the profile measurements using mercury in horizontal pipes, and in vertical pipes with both up and down flow. The maximum pipe diameter of about 5in will be greater than that in previous investigations. Previous profile measurements have been confined to two or three fixed diameters; it is proposed to develop a traversing system that will enable the profiles to be measured on any diameter in any position along the pipe. The heat transfer coefficient will also be determined, for comparison with previous results and as a check on the profile measurements. In many previous investigations with liquid metals, it was found that heat transfer was significantly reduced if the liquid did not wet the pipe wall; more recently, experiments have shown that the heat transfer can be reduced by an increase in the amount of gas entrained in the liquid, thus reducing its thermal conductivity. It is proposed to investigate these and other factors, partly in the main pipe apparatus and partly in a small pilot apparatus in which the physical conditions can be more easily controlled. The results from this apparatus will be comparative only. At present, both the main and pilot apparatuses are being developed. Initial pumping tests have been made with each apparatus to obtain handling experience.

Transport Properties.—Tables giving values of thermal conductivity and viscosity over wide ranges of pressure and temperature are urgently needed to aid in theoretical work and in the design of industrial equipment. There is a shortage of accurate experimental results; those that are available are scattered through the literature and there is little uniformity in the units in which the results are expressed. To remedy this as far as possible, the existing data are being collected, converted to standard units, and their accuracy assessed, with the ultimate object of producing standard tables.

As a subsidiary result of the collection of data, charts have been constructed showing the ranges of pressure and temperature covered by existing measurements and listing the sources of the data. These charts have been useful in demonstrating where further experimental work is required and give a rapid indication of where any particular results are to be found.

To make more experimental data available, an apparatus is being designed at M.E.R.L. for the measurement of thermal conductivity of important fluids up to high temperatures, and to pressures in excess of the critical. In addition, a contract has been placed with the University of Southampton for the determination of the thermal conductivity of fluids over a wide range of pressure, at temperatures between 20 deg. Cent. and the boiling point of nitrogen. A research contract has also been placed with Queen Mary College (University of London) to obtain measurements of the viscosity of liquid argon over a wide range of pressure and temperature.

(*To be continued*)

Birthday Honours

THE birthday of Her Majesty the Queen was officially celebrated on Thursday, June 12. An Honours List published on that day includes announcement of the following awards:

Knights.—Dr. Willis Jackson, director of research and education, Metropolitan-Vickers Electrical Company, Ltd.; Mr. J. S. Pickles, chairman, South of Scotland Electricity Board; Mr. C. A. P. Southwell, managing director, Kuwait Oil Company, Ltd.; Mr. R. W. Taylor, engineer in chief, Office of Crown Agents for Oversea Governments and Administrations, and engineering adviser to Secretary of State for the Colonies.

G.B.E.—The Right Honourable Walter McLennan, Baron Citrine.

C.B.—Mr. M. B. Morgan, deputy director, Royal Aircraft Establishment, Farnborough; Mr. F. I. Ray, director of Inland Telecommunications, General Post Office.

C.B.E.—Mr. D. Bellamy, chairman, Yorkshire Electricity Board; Mr. P. A. T. Bevan, chief engineer, Independent Television Authority; Mr. W. B. T. Blue, Commodore Chief Engineer, Peninsular and Oriental Steam Navigation Company, Ltd.; Dr. T. W. F. Brown, director, Pametrada; Mr. E. K. Cole, chairman and managing director, E. K. Cole, Ltd.; Mr. J. Corner, senior superintendent, Physics Division, Atomic Weapons Research Establishment, Aldermaston; Mr. J. Cowan, principal electrical inspector, Mines Inspectorate, Ministry of Power; Mr. J. E. Jackson, director, Royal Ordnance Factories, Ministry of Supply; Dr. R. Lessing, president, National Society for Clean Air; Mr. W. A. Macfarlane, chief executive, National Industrial Fuel Efficiency Services; Dr. E. S. Moult, director and chief engineer, de Havilland Engine Company, Ltd.; Mr. L. A. Sayce, superintendent, Light Division, National Physical Laboratory; Mr. F. S. Snow, consulting engineer; Mr. J. C. Thompson, deputy director, electrical engineering, Admiralty; Mr. J. L. King, resident engineer in London of Electricity Corporation of Nigeria.

Extensions to P.E.R.A. Laboratories

A large new workshop and laboratory building has been opened at the Melton Mowbray research establishment of the Production Engineering Research Association. This building, with a floor area of some 45,000 square feet, provides accommodation for extensive new machine tool, machining, metallurgical, metrology, electronics laboratories, and drawing and administration offices.

AN important stage in the development of the Production Engineering Research Association was completed on Tuesday, June 3, when Lord Chandos opened a large new workshop and laboratory building. Since the Association was established at Melton Mowbray some ten years ago, certain difficulties and restrictions have been experienced owing to a lack of adequate accommodation, as the workshops and laboratories have been housed in temporary buildings. This new modern building, with its floor area of 45,000 square feet, provides vastly improved facilities. In addition to the main workshop, shown in the photograph reproduced below, the building provides accommodation for laboratories concerned with machine tools, metrology, metallurgy, electronics and radioactive research, as well as drawing and administrative offices.

The work of this Association is now well known. Up to the present it has issued many valuable and interesting reports on nearly a hundred major research projects it has completed or has in progress. In addition, some 1200 investigations into specific problems have been carried out for individual firms. When the new building was opened visitors were given an opportunity to see the equipment on which many of the research projects are being carried out, and given some appreciation of the vast amount of detailed development work which forms the essential background of the activities of P.E.R.A. It was quite evident that the increased space and facilities made available by the new extension are already being used to good effect for the research work in progress, which is both varied and interesting and will doubtless result in a number of valuable reports in the future. It is not possible to list in full or describe in detail all the work in progress at the establishment, but these brief notes will give some indication of its scope and importance to industry.

What may be broadly termed metal cutting research forms an important part of the Association's work and the comprehensive programme in hand includes means of determining the relative machining properties of plain carbon and free machining steels in various metallurgical conditions when turning with high-speed steel tools. Practical work in this connection has been completed and the report on the investigation is now being prepared. An investigation is being made into cutting fluids and methods of application when turning alloy steel with carbide tools. Comparisons are being made of the performance of lathe tools and twist drills manufactured from various high-speed steels when machining alloy steel. A study is being made to determine the effects of various types of point thinning on drill life and drilling torque and thrust when drilling medium carbon steel. In connection with reamers an investigation is in hand to determine the effects of shape, wear and cutting conditions on the accuracy and surface finish of reamed holes in low carbon steel. Among the investigations now in the preliminary stage is one into milling to determine the effect of tooth shape and cutting conditions on the performance of milling cutters. For investigations into the use of radioactive techniques in connection with tool performance tests a special section of the main machine shop has been screened off and equipped with a modern lathe and the necessary instruments.

The cold extrusion of metals forms the subject of another series of investigations, and for this work a single-action British Clearing press has been introduced particularly for research into the cold extrusion of steel. This machine has a rated capacity of 1000 tons at 6in from the bottom of its stroke. As is generally known, the principal advantage of cold extrusion is the facility with which a wide range of components can be produced in a single stroke of a press with relatively simple tools from a cold slug of metal. During cold extrusion, the metal is stressed compressively and much larger deformations can take place than when the material is deformed in tension. One cold extrusion operation, for example, may replace several deep drawing operations with interstage annealing. Close dimensional tolerance can be maintained and as wall thickness and base thickness are independent of each other, greater freedom of design as compared with deep drawing is possible. It is considered by P.E.R.A. that the most promising field of application for cold extrusion, which has yet hardly been touched, is the replacement of machined components by cold extrusions.

The materials which can be extruded, as well as the proportions and size of components, are limited by the large forces required. However, this is not such a serious limitation as it might first appear to be, as the drastic cold working performed during cold extrusion confers excellent properties on the materials, and extrusions in low or medium steels often have mechanical properties similar to those of heat-treated carbon and low-alloy steels.

Future research into cold extrusion will be increasingly concerned with the problems raised by applications of the process to a wide range of components in steel and other high-strength materials. The specification, micro-structure and physical properties of the material are of critical importance in successful cold extrusion, and the effects of these factors are now being investigated for steels containing up to 0·3 per cent carbon. A further factor of fundamental importance in the cold extrusion of steel is the lubricating of the slug, and investigations are in progress to determine the effect on extrusion forces of the thickness of phosphate coating and its crystal size.

In addition to fundamental investigations into work materials, slug lubrication and extrusion speed, pilot development projects are being carried out to determine the practicability of cold extruding particular components required by industry.

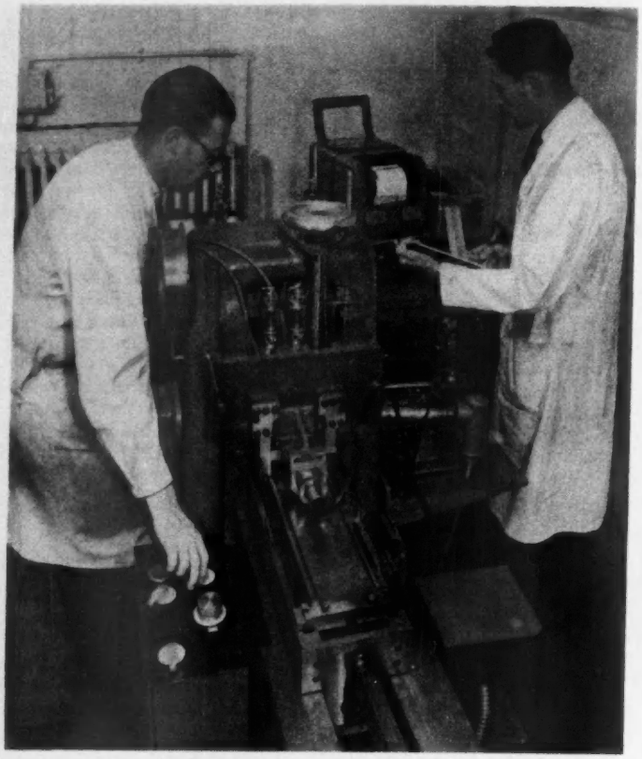
Research has been carried out into the finish blanking technique which produces smooth edges in contrast to the relatively rough edges produced by conventional blanking techniques. With conventional blanking techniques, it is usually possible with thin components to obtain a sheared surface which is reasonably square and free from cracks by decreasing the clearance between punch and die to about 2 per cent of the material thickness per side. However, with thicknesses of material greater than $\frac{1}{4}$in, decreasing the clearance between punch and die seldom gives particularly satisfactory results.

A method of obtaining a good finish on the sheared surface in a single press-working operation, particularly on thick blanked components, was shown in the laboratory. In this method there is employed a very small clearance between the punch and die in conjunction with a die provided with a small polished radius at the die mouth in place of the normal sharp cutting edge. A programme of research has been carried out to explore the advantages and limitations of this finish blanking process and to provide reliable data on clearance and radius which

Main workshop of new laboratory building. The enclosed sections along the wall in the background house the electronics and radioactive research stations

could be used by industry. Recent investigations have shown that straight carbon and even alloy steels can be satisfactorily finish blanked to give a sheared surface condition which is at least comparable to, and in many cases better than, shaving. In most of these cases substantial economies have resulted from the elimination of shaving and other ancillary operations previously required to obtain the desired quality of finish on the edge of the component.

The general objective of machine tool research by P.E.R.A. is to determine the principles of design, construction and operation which contribute to the highest efficiency in the manufacture and use of machine tools. Such research normally includes a study of the accuracy of machines, observations of power and efficiency, machining tests, deflection tests and vibration tests. Substantial progress has been made in an investigation into various aspects of machine tool slideway lubrication and slideways using the set up shown in the accompanying illustration.



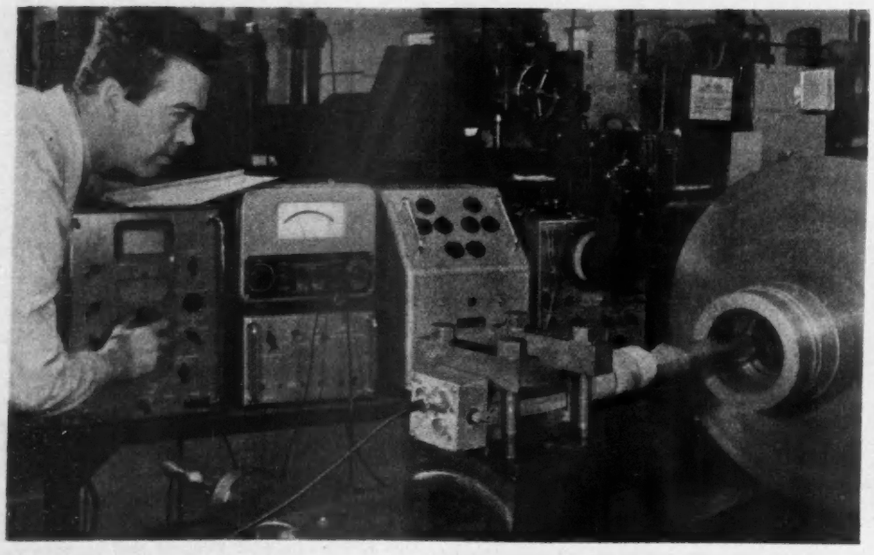
Laboratory rig for research into friction and lubrication for machine tool slideways

This apparatus, which simulates the conditions prevailing in a typical machine tool slideway, consists basically of a cast iron bed having horizontal slideways which are machined flat and parallel. A cast iron carriage fitted with five pairs of roller bearings runs on the horizontal bed slideways and is guided by two pairs of ball bearings which roll on vertical machined faces on each side of the bed. The carriage can be reciprocated by either of two hydraulic cylinders at velocities varying from approximately 0·002in per minute to 350in per minute, over a stroke of 30in. Provision is made for measuring the velocity of the carriage. The lower test surface is mounted on the moving carriage and supports the upper test surface, the motion of which is restrained by a force measuring system. Provision is made for lubrication and also for applying predetermined loads to the test surfaces.

A report is at present being prepared on the influence of different kinds of surface, lubricant viscosity, load per unit area, and sliding speed on various factors, including the transition from boundary to hydrodynamic lubrication, stick-slip, friction forces, &c. Practical research is in progress to determine the friction properties of various lubricants and machine tool slideway materials.

An interesting series of investigations is being carried out in connection with the causes and effects of vibration of machines and cutting tools, and a special section for this work has been set aside in the new main workshop. The section is isolated from the main structure to eliminate the effects of vibration from other machines. This work is of importance as present limits of speed, feed, tool life, surface finish, and accuracy in everyday production practice are often set by the vibration characteristics of machines and cutting tools. Although the difficulties caused by vibration are usually readily apparent in operations such as boring and milling, in many apparently vibration-free operations the limits on output and quality are, in fact, often imposed by minute undetected vibrations. It is pointed out by P.E.R.A. that full understanding of the nature and effect of these vibrations will help to remove present barriers to substantial increases in the efficiency of existing techniques, facilitate the development of new techniques, and lead to more efficient utilisation of carbide and ceramic cutting tools.

Several general investigations into vibration characteristics of various kinds of machine tools have been completed and some interesting results obtained. One of the investigations in progress in this connection is illustrated below; a boring bar fitted with a vibration absorber is shown in operation on a lathe.



Lathe equipped to determine the vibration damping characteristics of an experimental damped boring bar

Books of Reference

Careers Encyclopedia. Edited by G. H. Chaffe and P. J. Edmonds. Cleaver-Hume Press, Ltd., 31, Wright's Lane, London, W.8. Price 15s.—This is the second edition of a reference book which furnishes helpful information as to qualifications, entry and prospects in about 240 professional and commercial careers. Particulars about careers in engineering are usefully classified under four main headings, namely, civil, mechanical, electrical and chemical. The appendices to the main text include details about scholarships, correspondence colleges and careers of special interest to women.

Aluminium and its Alloys in Electrical Engineering. The Aluminium Development Association, 33, Grosvenor Street, London, W.1. Price 20s.—This volume contains the papers which were presented for discussion at the "Symposium on Aluminium and its Alloys in Electrical Engineering," held in May, 1957, together with the discusion and the authors' replies, all of which are reproduced in full. The fourteen papers are arranged in three groups, corresponding to the sessions during which they were discussed, and accompanied by the related discussions. Three papers are concerned with the general and economic considerations in using aluminium in electrical engineering, a further three deal with the question of aluminium in transmission and distribution lines while the remaining eight papers relate to problems in the use of aluminium in electrical equipment.

Directory of Shipowners, Shipbuilders and Marine Engineers, 1958. Fifty-sixth edition. Tothill Press, Ltd., 33, Tothill Street, London, S.W.1. Price 40s.—The directory provides in handy form and within a small compass a ready access to a large amount of information concerning shipbuilders and owners. The largest section of the book deals with the latter group and totals 580 pages which give details of the fleets, the main technical particulars of the ships, including the date built and the names of the builders. Particulars of shipyards, marine engine builders and ship repair facilities are set out in detail and the information includes overall capacity, number and size of berths and machinery built. For both groups the names of the directors and technical officials are listed. Following these two sections are lists of trade and technical organisations, consulting naval architects, marine engineers and ship surveyors, experimental tanks, classification societies and Government departments. There is a ship index in which ships are linked with owners, and a geographical index of shipowners and builders.

Electrical Component Manufacture

We recently visited The Plessey Company, Ltd., at Towcester, to see the manufacture of electrical components such as magnetic ferrite cores for memory stores in computers. In order to give very low input demands, these components tend to extremely small sizes.

IN discussing the adoption of ceramic magnetic materials in the United States (" Revolution in Magnetics," The American Scene, August 16 last year), we observed that the makers of ferrites were taking up the manufacture of memory stores. The British licensee of the General Ceramics Corporation, The Plessey Company, Ltd., has followed this lead and is producing complete memories at its Chemical and Metallurgical Division. These information stores are in service in computers made by such firms as E.M.I., Ltd. : it is considered that, because they allow random access to any " bit " of information and have an access time of only 0·01 millisecond, they have a secure future in computers as working stores. The density of the store is also good,

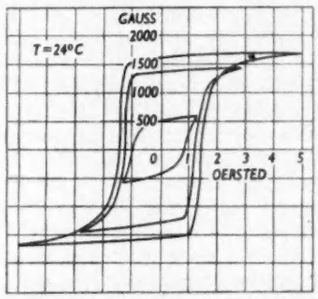


Fig. 1—Typical hysteresis loops of " Ferramic " S1

at 4000 bits per cubic inch compared to 2000 for a magnetic drum, although it can be foreseen that the development of ferro-electric stores to satisfactory standards of time stability will allow a random access memory with 200,000 bits per cubic inch to be attained.

The form of the ferro-magnetic element is a toroid. This is threaded on wires, thus achieving a high degree of coupling between magnetic and electric circuits. The principle of access is that wires run in both the x and y directions through each core : the current passed along each wire is insufficient to upset the stable state of the cores on this wire, except that one core which is being driven also by a wire in the other direction. (The bi-stable nature of the magnetic cores is shown by our figure : the term " square loop " ferrite is clearly justified.) In this way any one core in a plane of, perhaps, 64×64 cores can be reached : selection of the appropriate co-ordinates is done by flip-flops connected through gates to driving valves or transistors. The processes of impressing and removing information are virtually the same : when the bit is interrogated by a driving pulse, a sensing wire which passes through all the cores in the plane is monitored—if the core changes its state, a pulse will be induced in the sensing wire. In order that the stored information shall not be degraded, in case of a positive response the bit must then be restored to its initial state by energising the x and y wires again in the opposite directions. The accompanying illustration shows a plane being assembled by female labour : the diagram in the background shows how the sensing wire covers the entire area, running at 45 deg. to the x, y axes.

The small size of the individual cores is due not only to the need to save space, but also because the driving outputs obtainable from presently available transistors are lower than from valves : for this reason cores of 0·080in diameter are now supplemented by others of 0·050in o.d. and 0·030in i.d. Assembly is in all cases by hand, consisting essentially of threading wire through with a needle, even as in sewing fabric. The work is done by female labour ; the shop is particularly clean and well lighted, and the work attracts recruits. Terminal connections are made by soldering.

Inspection, both of cores and assemblies, is clearly a major task. Inspection of the cores is highly mechanised ; a " Sinex " feeder delivers them successively to the test position, where a probe is passed through the central hole to complete an electric circuit. Currents large enough to change and small enough not to change the state of a good core are then applied and the response presented on a c.r.o. display : the operator presses the " pass " button if the one trace is above and the other below set limits and the " fail " button if not. Circuit testing of assemblies is exceedingly laborious : at present it is done manually and the results recorded by pencil and paper methods, but automatic techniques of testing, if not recording, are under development.

Another application of ceramic compounds of specialised properties is in gramophone

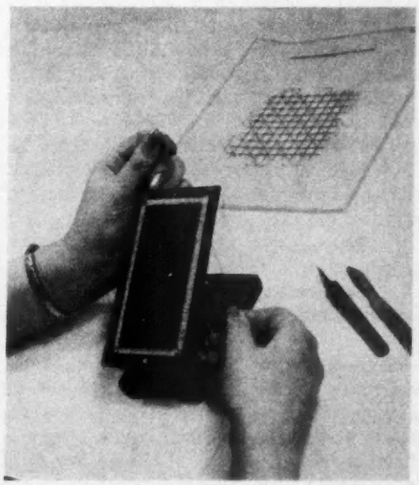


Fig. 2—Ferrite cores being threaded by an assembler using a special needle

pick-ups with barium titanate transducers. These allow the pick-up stylus to be of very light construction with a correspondingly high frequency response. These transducers have been applied to the reproduction of stereophonic sound by cutting into the record two tracks, inclined at 45 deg. in a section through the axis of rotation, in the same groove : the movement of the stylus is resolved in the corresponding directions by

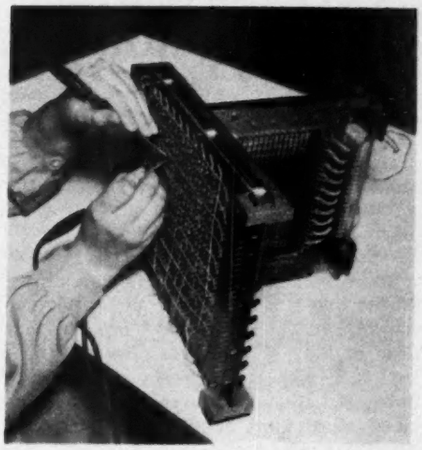


Fig. 3—Continuity testing of memory stores requires concentration and skill, since each minute termination and winding must be tested individually

two transducer cartridges at right angles. If the two tracks were excited by microphones subtending 90 deg. to the sound source, and the two outputs are fed to speakers subtending the same angle to the audience, a realistic impression of being in the presence of the original sound is created. This development has been undertaken by Technical Ceramics, Ltd., a subsidiary of Plessey and Sonotone of the United States : records are distributed by the latter.

The Plessey Company have applied to the detection of infra-red radiation the photo-electromagnetic effect in single crystals of indium antimonide. (The action of radiation is to produce electron/hole pairs at the face of the crystal, and the resulting concentration gradient forces them back into the material. A transverse magnetic field causes the two kinds of charge carrier to tend in opposite directions and thus causes a signal voltage to appear across the crystal.) Such a detector not only has a fast response ($<1\mu s$) but also a high maximum frequency that allows it to work in the 2–7 microns band (frequency 1·5 Mc/s to 0·43 Mc/s) : this means that the incident radiation can very conveniently be focused by quasi-optical methods. It was demonstrated to us that this cell, with the incident radiation being chopped mechanically to give an alternating current signal for easy amplification, could detect the difference in temperature between a human hand and its surroundings. It is claimed that if a telescope were used to focus the radiation, it would be possible to detect the temperature rise, of the order of unit degrees, in a live electric transmission line as much as 1 mile away. It is intended to develop a detector combined with a transistor preamplifier giving a 60 db gain, in order to avoid the need for a special low noise level amplifier.

REMOTE LEVEL CONTROLLER.—An improved capacitive liquid-level controller is announced by J. Edward Hall (Electrical Engineers), Ltd., Clarence Road Works, Leeds, 10. Called the " Proxicon Mark III," the instrument can be supplied for multiple-level work, and the maker quotes applications involving up to twenty-four high and low level control points in one combination. Control is possible from 3000ft away, using standard cable. In the new model the P.O. relay has been replaced by a heavy-duty contactor relay, and a circuit has been added to make the action sharp even when slow movement of level causes slow change in capacitance. Improved construction is stated to provide sensitivity better than 1·0 pF under all conditions, mains fluctuation of +5 per cent to −7½ per cent varying this by ±0·25 pF, and temperature fluctuation in the range 68 deg. Fah. ±20 deg. Fah. varying it by not more than ±1 pF.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—After thirty-nine letters, two leading articles and a book review, all on this one subject, Mr. C. A. Kershaw's letter in your issue of May 30 stands as something of a landmark with its advocacy of the pilot principle. His pilot conversions would only be of branch lines, but at least he voices the principle. He doubtless carries with him many people, including Mr. K. B. Freeman whose thoughtful letter you published on May 16 ; the branch lines are their common target. There was a different, better target in your leading article of April 25, though admittedly it was for study only ; it comprised a main line and some separate suburban route or routes : again many people must have agreed with that. May I now plead with all concerned to raise their sights just a little and aim at the pilot conversion, not merely the study, of an assortment of lines, not merely branch lines, so that maximum experience may be gained ? Experience in this particular field is sadly lacking. In the general field there is ample foreign data on the usefulness of special roads for motor traffic but, unfortunately, in their siting and alignment the foreign motor roads display few or none of the characteristics of a British railway. For instance each one of them is either a rural throughway or an urban expressway, whereas British railways when converted will be both : they will be Through Rural and Urban Express-WAYS. Theory indicates very positively that they will live up to those initial letters, but Mr. Kershaw's principle rightly demands the application of practice. Practice is required quickly, too ; for a full scale inquiry into Britain's transport problems is certainly looming, and the key question will concern the future of the railways. Should they be modernised as railways, or futurised as roads reserved for fast motor traffic? Without pilot conversions it will be hard to decide.

One interesting argument that will be settled by trial conversions concerns elevated roads constructed above railways. Mr. P. Snowden Murray, who suggested these in your issue of April 25, may like to know that Colonel S. M. Lovell has spoken at the Institution of Civil Engineers as the protagonist of this form of construction, just as Mr. N. M. Brydon has spoken for the same form of construction striding above town and country, not along the railways. Colonel Lovell has put his cost at £750,000 per mile, and Mr. Brydon his at £200,000. Those figures give some indication of the capital expenditure Britain will need to incur on roads if railways are to continue sacred. But trial conversions are likely to show that the capacity of the entire railway system when converted will be such that Britain will need scarcely any more roads at all, up in the air or on the ground. The very few stretches of railway formation that might constitute bottlenecks are already being rectified under the railway modernisation scheme : e.g. Potters Bar, Barking and St. Mary's Cray in the London area alone.

T. I. LLOYD

123-4, Newgate Street,
London, E.C.1,
June 1, 1958.

SIR,—Since my letter in your issue of April 18, the Ministry have announced that they are going to incorporate the 3 miles between Dowlais Top and Tafarnaubach, on the Abergavenny–Merthyr line, in their improvement scheme for the Heads of the Valleys Road.

This section least requires duplication, as it has easy gradients and by-passes only one small village. Plans for the section where heavy gradients would make duplication most advantageous, between Abergavenny and Brynmawr, are said to be too far advanced to reconsider, though there are no signs of activity on the ground at present.

A central section of 8 miles which would provide economical by-passes for both Tredegar and Beaufort is not being entirely closed, but local residents tell me that it is only used for three or four trucks of coal a day.

It is difficult to understand how the B.T.C. can block road development of this kind, especially as their avowed policy is to cut out uneconomic lines and services.

Given good will on their part, there would be very real possibilities of economical by-passes for both Abergavenny and Merthyr, by the use of abandoned or uneconomic sections of track.

Now that the only hope of British Railways paying their way is to "contract to their profit earning core" surely this is the time to co-ordinate our transport system and incorporate uneconomic track into our inadequate road system.

This latest announcement only goes to show that British Railways are determined that railway property shall not be used to improve the road system of the country.

D. F. C. VOSPER

Nantyrhogfaen,
Llandovery, Carms,
June 1, 1958.

SIR,—Railways first came about when there were no motors and no good roads. I ask myself whether, had there been good roads and motors in 1825, railways would have come into being. If the answer is in the negative, then clearly the time has come about when railways should be abolished.

At the same time however, as we have railways, there would undoubtedly be many physical difficulties in adapting a system which has been designed and built to carry rail traffic. Nothing less than a dual carriageway would be practical or safe for motor traffic. High embankments, with or without parapet walls, would be dangerous, and tunnels would be too narrow for the carrying of dual carriageways.

As for accident statistics, we have available those for railways, but none for existing railways after conversion into roadways (to be used only by coaches and commercial vehicles), as accident statistics for existing roadways would give no real guide.

Corners, as understood by present-day road users, are non-existent on railways, and gradients are so gentle that lorries could possibly operate with more economical engines (smaller cubic capacity) than are necessitated on present-day roadways.

In the event of railways being converted into roadways, how would essential transport carry on in the meantime ? During short periods (railway strikes) road transport has managed the job.

HAROLD W. BUTCHER

Hereford,
May 30, 1958.

SIR,—Mr. Gordon England specifically declines to promise that one will be able to write legibly in any foreseeable road vehicle moving at any useful speed. The best he seems able to say about his figures are that they are from (un-named) "authoritative sources," which is a commonly used synonym for "guesswork." Any sum of money quoted as a saving by reduction of journey-time is bound to be guesswork until it is proved that, in consequence of it, someone did something useful and assessable. Mr. England gives a reluctant assurance that conversion will result in "reduced cost of travel, greater comfort, much saving of wasted time and reduced taxation." These being exactly opposed to all recent experience and being at least superficially attractive, Conversion Leaguers would surely have put them at the front of the platform with full supporting evidence had they had any solid reason for believing them. Mr. England (according to his own sentence) deprecates "dependence upon assertion and conjecture." Please let him prove to us (spurning "authoritative sources") that conversion of all British railways to super-autobahnen must inevitably force taxation down by so many per cent in so many months. Let it be a mere fifty in twelve months and we will try to endure the bumps and lurches and will not ask Mr. England to persuade us that we have only imagined them.

W. A. TUPLIN

Sheffield,
June 2, 1958.

SIR,—Your correspondents have raised a great many arguments both for and against railway conversion, but they still seem no nearer to agreeing. Could it be that the two sides are arguing at cross-purposes ? Does the pro-road faction base its rejection of railways on the assumption that the railway of the future will be like that of to-day—only "modernised" ? Can it be that the pro-rail faction is beginning to see that scrapping the rails is only a comparatively minor part of Brigadier Lloyd's proposal and that they can obtain most of his benefits while still keeping the rails ? Surely, the real argument is not whether flanged wheels should make way for rubber tyres but rather

this : should the main transport system of the country continue to be inflexible and only partially reconciled to the developments of the twentieth century or should it be truly adaptable to the needs of the nation ? There seem to be no fundamental reasons why the railways should not, in time, give us all that the motorway promises and, in addition, leave us with a guided system that can work from cheap electricity and, who knows, without drivers. Brigadier Lloyd considers that British Railways are doing the best job they can. I believe that this is where he is wrong. British Railways may be making a good job of modernising the railway to nineteenth century concepts. They do not yet show many signs of appreciating that a fundamental change of approach is required —or even possible.

This letter would be incomplete without an indication of some of the ideas that should be considered for transfer from road to rail : such things as high deceleration—a most potent producer of high capacity ; signalling that takes continuous account of the positions of the vehicles and their relative speeds ; switches that can be changed from moving vehicles ; " wagons " with their own individual motors so that they can move independently or be coupled into multiple-unit trains ; removable bodies (containers) for quick turn-round of the expensive chassis. These ideas may sound ridiculous, yet they pay dividends on the roads.

D. L. TURNER

Derby,
June 6, 1958.

SIR,—I read with interest Mr. Lloyd's reply to my letter and I find that he agrees with me in the main point, namely, that if railways are converted to roads then regulations, &c., will have to be brought in to control the traffic on these roads.

Now this is the thin end of the wedge, for a road which is built and maintained by public expense has to grant the public unrestricted access to it ; therefore, the League and Mr. Lloyd cannot deny these roads to all but " fast traffic " unless they build them and keep them as private property, charging tolls for their usage.

Also, in any case, to maintain a degree of safety on these roads in any way comparable with the railways, the rules and regulations would have to be pretty comprehensive, but as I stated in my letter, road transport has grown up and flourished on the " freedom " of the roads. Accordingly, many road users of to-day would feel themselves unable to face up to regulations on such a scale, would withdraw their vehicles and fall back on professional transport for, to them, the roads would have lost all advantage over the railways.

Also, of course, the sorting-out of the sheep from the goats in using these roads would lead to a lot of controversy and much ill-feeling all round, since it is now quite clear that Mr. Lloyd visualises these roads as being reserved only for fast and powerful private cars, a few motor-coaches and possibly one or two lorries that could stand the pace.

Whereas nobody doubts the ability of the civil engineer to carry out the conversion, the impression gained from the correspondence is that the roads thus produced would not necessarily be intelligently used.

J. R. M. THOMAS

Bristol,
June 8, 1958.

Book Reviews

Centrifugal and Axial Flow Pumps : Theory, Design and Application. Second edition, 1957. By A. J. STEPANOFF, Ph.D. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 96s.

THIS is the second edition of a work first published in 1948 and now larger by thirty-four pages, the increase being principally due to the addition of a nineteenth chapter on " Water-Hammer Problems in Centrifugal Pump Systems," to the other eighteen which retain their former titles and numeration. Opportunity has been taken to redraw and reletter many of the diagrams, and to enlarge them, thus improving general appearance and legibility. New illustrations, too, have been introduced, notably in Chapters 16 and 17, in an endeavour to show examples of such modern practice as nuclear reactor coolant pumps and high-pressure boiler feed and boiler circulating pumps. Nevertheless, a high proportion of the book remains substantially unaltered, particularly in the earlier chapters, and there are no significant changes in the author's approach to his subject. The treatment throughout remains frankly empirical, and the author specifically rejects any idea of a theoretical investigation of the proportions and design of impellers and volutes so painstakingly undertaken by Continental and especially German writers. Nowhere are there any references to the researches in progress at the California Institute of Technology, or in various European countries, to elucidate the true nature of the flow in impellers and volutes, and to correlate those results with any form of hydrodynamic theory.

The author admits that progress cannot be made without experimentation and the designer's skill " to sort out values leading to the optimum efficiency," but he gives us no very clear idea as to the basis of reasoning upon which that skill is to be built up. The theory of the centrifugal pump impeller is still developed largely along classic lines, although it is refreshing that one writer at least admits the futility of attaching a physical meaning to the individual terms of the Euler equation (3.7). It is noticeable that although relative circulation within the impeller is still dealt with, all reference to the Pfleiderer correction and other European attempts to theorise on this subject has now been omitted. On the other hand, it is curious that the author continues to devote no less than three pages to " Theoretical Head with Non-Uniform Meridional Velocity," a subject, surely, of small practical interest and at variance with the general outlook of the work.

The design of impellers and volute casings based on empirical coefficients plotted against specific speed remains unchanged from the former edition, as does the unfortunately named " method of error triangles " for the design of mixed-flow impellers. Slightly more space is now given to the diffusion casing (Section 7.5), and the author admits European achievements in this field and gives illustrations of them. The treatment of the axial-flow pump in Chapter 8 has been revised, and the aerofoil theory is allotted more space, but only with constant reminders of its shortcomings and the need for the designer to interpret test results with the aid of " a continuity of mental pattern of flow, theoretical reasoning, and geometrical design procedure." Once again, one wonders how he acquires the second of these desirable attributes and what the author means by the first. New material on pump turbines is a welcome addition to Chapter 13 and includes a section through the Sulzer pumped storage machine at Grimsel. The chapter on centrifugal jet pumps has been extensively rewritten ; it will probably surprise English readers to learn from the preface that this chapter has brought more comment than any other. The new final chapter on water-hammer is a useful addition for many pump engineers who will appreciate a simple exposition of the Bergeron graphical solution, now widely used.

It is understandable, but regrettable, that so many of the assertions on various topics are apparently based on, or at least illustrated by, tests on very small pumps, some of only 1½in or 2in branches. Much may be done with models, but it is surely dangerous to form reliable opinions based on tests of small commercial pumps with all their manifest possibilities of error. The book remains, therefore, much as before, with its curious mixture of shrewd practical advice and unsupported dogmatic assertions based solely on the author's experience, but not necessarily universally true on that account. Nevertheless, with so few modern treatises on the subject, one cannot afford to ignore this notable contribution ; there is nothing quite like it, and for that reason, if for no other, one is compelled to go repeatedly to its pages for information and assistance. It is all the more regrettable that its high price in this country will tend to restrict it to the shelves of the technical library and may deter a good many owners and users of the former edition from bringing themselves slightly more up to date.

Indeterminate Structural Analysis. By J. S. KINNEY. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, U.S.A. (British Agent) Academic Books, Ltd., 129, Queensway, London, W.2. Price 76s.

THIS book, one of many published on the subject in recent years, sets out in a logical way the many methods available to engineers for solving indeterminate structures. Although it derives the methods from first principles it does assume that the reader has a thorough knowledge of determinate structural analysis. An excellent first chapter gives briefly the history of structural theory, which is a subject more engineers should be familiar with. Next follow chapters giving the basic theories and concepts used later in the book. After this introduction all the usual methods of analysis are discussed in detail and all the relevant formulæ and theorems derived and proved ; in this section, too, a great number of worked examples are given. Finally a chapter is devoted to model analysis, a method which does not appear to find much favour with many British engineers.

This book is essentially a students' book in that all the methods are described impartially and only occasionally are hints given as to the best method for any particular problem ; nevertheless Southwell's relaxation method and Baker's method of plastic design are not dealt with although references to the methods are given in the bibliography. Nor are space frames dealt with as such. Strain energy, conjugate beams, least work, column analogy, slope deflection and moment

distribution are all described, although the section devoted to column analogy is short and is perhaps the least successful part of the book since, instead of starting from a simple idea, it plunges directly into the more complex and so tends to obscure the power of the method.

The section devoted to moment distribution is by far the longest and is dealt with thoroughly, including different degrees of joint translation and non-prismatic members.

As stated in the preface, the treatment is detailed, extensive and rigorous and for that reason perhaps one is left with the feeling that this side has been overdone and the whole appears to be more complicated than it really is. The completely general case is proved first where a simple example might have been a better introduction.

The number of worked examples is more extensive than is usual in similar books. In addition numerous references are given at the end of each chapter. The text is essentially for students ; the worked examples are, however, useful not only to the student but also to the practising engineer who should find here not only a method of analysis to suit his temperament but also a problem similar to one which he has to solve.

Mechanical Resolution of Linguistic Problems. By A. D. BOOTH, L. BRANDWOOD, J. P. CLEAVE. Butterworth and Co. (Publishers), Ltd., 88, Kingsway, London, W.C.2. Price 50s.

THE preface states that the purpose of this book is to record the techniques adopted by the authors in their work on the application of digital computers to linguistic problems. One might expect to find that the approach is so detailed and specific that the book is of interest only to the specialist in this field. However, this is true of certain parts only and many of the chapters are of general interest.

A short historical introduction is followed by a very condensed description of the facilities provided by conventional punched-card data processing equipment and by electronic digital computers, with particular reference to the Birkbeck College computer, APEXC, on which the practical translation work was carried out. The next five chapters deal with methods of handling a variety of language problems. Automatic translation from one language to another has received most attention from workers in this field, and also considerable press publicity, because of the immediate practical possibilities it provides for speeding up the interchange of information. However, just as computers handle calculations which would have taken too long to solve by manual methods, so they may take over the preparation of concordances and the stylistic analyses used in estimating the relative dates of a series of literary works or in determining the authenticity of particular manuscripts.

All these problems require a dictionary of words stored within the computer in order that a word presented to the machine input may be recognised and classified. Various methods of searching through this dictionary are analysed to determine which requires the minimum average time. The use of separate " stem " and " ending " dictionaries, which is an essential feature of the authors' approach, is explained in detail. A French or Latin verb, for example, may have thirty or forty different forms covering the different tenses and persons. The " stem " dictionary is used to store that part of the verb which is invariant for all or most forms and is used to identify the basic meaning. The " ending " dictionary stores those parts of the verb which vary with tense, &c., and is used to identify the particular form of the basic meaning. One set of " ending " entries may serve for many different verbs, so that a substantial saving in storage requirements is possible.

A simplified programme for APEXC for the translation of French into English shows the practical application of ideas discussed in previous chapters. This is followed by over 130 pages dealing with the problems to be faced in translating from German to English. The last few pages of the book briefly consider translation of other languages and attributes desirable on a computer designed for translation. There is no doubt that the book achieves the purpose stated in the preface, but it is unbalanced for the less specialised reader by the long section on German translation. Nevertheless, the earlier chapters are well worth reading by anyone with an interest in this field.

Biochemical Engineering. By R. STEEL, M.Sc., Ph.D. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 50s.

THIS volume, which opens with an introductory lecture entitled " The Principles of Biochemical Engineering " by Sir Harold Hartley, is an expanded version of a course of ten lectures given at Manchester College of Science and Technology. Specific aspects of the subject are covered by the authors, each of whom is an authority on his particular subject. The lectures are arranged in the following order: " The Scope of Biochemical Engineering"; " Micro-organisms and their Activities "; " Substrates for Fermentation Processes"; " Sterilisation of Equipment, Air and Media"; " Development of Anaerobic Fermentation Processes Acetone—Butanol "; " Oxygen Supply and Demand in Aerobic Fermentations"; " Development of Aerobic Fermentation Processes " : " Penicillin " ; "Equipment Design" ; " Recovery of Fermentation Products "; and " Present Trends and Future Developments." The industrial application of biochemical processes involves the biochemist, the microbiologist, the geneticist and the chemical engineer , and the subjects covered by this book should make it an invaluable text and guide for all engaged in the complex field of biochemical engineering

Railways and Steel. Issued by the Economic Commission for Europe. Sales Section, European Office of the United Nations, Palais des Nations, Geneva, or Sales Agent for U.K., H.M. Stationery Office P.O.B 569, London, S.E.1. Price : 4s. 6d.

THE Steel Committee of the United Nations Economic Commission for Europe (E.C.E.) considered that an examination of the future trend of demand for railway material and rolling stock would be of value. The E.C.E. Secretariat, therefore, published a report which is the third of a series devoted to an examination of the economic aspects of trends in the production and consumption of important steel products, the two already published being "The European Steel Industry and the Wide-Strip Mill" and "The European Pipe and Tube Industry." On the basis of this report, the demand for steel by the railways is likely to remain approximately constant for some years, while continuing to account for a slowly declining proportion of total steel consumption. These overall trends conceal a number of important variations which are outlined in the E.C.E. study, which considers the following topics : production of railway material and rolling stock ; factors affecting the demand for steel by railways ; official programmes in the railway field ; overseas export prospects. In a number of appendices, extensive additional information is given on the production of permanent-way material, tyres, wheels and axles and rolling stock ; the age structure of Europe's railway-vehicle park ; the number of railway vehicles placed in service in recent years ; the length of railway networks and the importance of the vehicle parks of practically all the countries in the world ; and underground railways. A list of the international non-governmental railway organisations is also given, explaining their aims and the nature of their work and describing briefly their spheres of interest.

The Iron and Steel Industry in Europe. A study by the O.E.E.C. Iron and Steel Committee. The Organisation for European Economic Co-operation, 2, rue André-Pascal, Paris (16e). Obtainable from H.M. Stationery Office, P.O.B. 569, London, S.E.1. Price 10s.

THE report, *The Iron and Steel Industry in Europe*, recently published by the O.E.E.C. Iron and Steel Committee, is on the same lines as that published by the O.E.E.C. last year, but contains a more detailed study of manpower and productivity, as well as a new section which deals with trade between the E.C.S.C. countries and also with trade between the O.E.E.C. and non-O.E.E.C. countries. In the conclusions, particular attention is given to current problems of the iron and steel industry, including the pattern and structure of investments, the labour situation, and productivity. Other matters which come under review are production costs, demand, trade, and prices of iron and steel products.

Hydromechanik. By M. J. ALFERJEW. B. G. Teubner Verlagsgesellschaft, Goldschmidtstrasse 28 (Leipzig C1). Price: DM.11.30.

THE present book is the German translation of a Russian work on hydromechanics first published in 1952, and is intended as a textbook for university and technical students. All basic theory is fully covered on the basis of Bernoulli's and Euler's equations, and particular attention is paid to the applications to ships and wave motion, a fact due to the book being originally written for students of the technical courses sponsored by the Russian merchant navy.

Books Received

Programming for an Automatic Digital Calculator. By K. H. V. Booth. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 42s.

Ten Division Influence Lines for Continuous Beams. Eighth edition. By Dr. G. Anger. Constable and Co., Ltd., 10, Orange Street, London, W.C.2. Price 47s. 6d.

Electricity Undertakings of the World. Sixty-eighth edition, 1957–58. Benn Brothers, Ltd., Bouverie House, 154, Fleet Street, London, E.C.4. Price 30s.

Sixth Symposium (International) on Combustion. By the Combustion Institute. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 224s.

Dock and Harbour Engineering. Volume I. The Design of Docks. By H. F. Cornick. Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C.2. Price 105s.

Hotels and Restaurants in Great Britain and Ireland. Thirtieth edition, 1958. The British Hotels and Restaurants Association, 88, Brook Street, London, W.1. Price 3s. 6d.

Solution of Problems in Electrical Technology. By H. Cotton and P. V. Parry. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 20s.

Gatwick Airport

Her Majesty the Queen inaugurated the new airport at Gatwick on June 9. The airport will handle certain of the shorter routes—notably to the Channel Islands—and will serve as London's second airport, giving an alternative landing if London Airport is fogbound. The first stage of construction, involving one runway, and costing £7,000,000, is now complete ; it is noteworthy in incorporating the most recent airport practice, and in bringing together road, rail and air transport. Technical matters of special interest, such as the runway construction, the runway lighting and the telecommunications are concentrated upon in this article.

MUCH of the general background to the development of Gatwick Airport, and its particular functions, will by now be well known, since the new airport has been extensively described in the press following upon its inauguration by Her Majesty the Queen. But apart from the special facilities offered by uniting rail, road and air transport, the airport's design represents the best of modern practice and has some innovations. The illustration above gives a bird's eye view of the whole development. In the foreground is the railway station, from which the station footbridge leads directly into the main hall of the terminal building, which is at the same level as the footbridge. The London-Brighton road passes under this hall, and ramps lead off it to an elevated roundabout serving the terminal building. Passengers pass along the long " finger " or pier to aircraft standing beside it. A system of taxiways connects with the runway, which can be seen in the background. The control tower can just be seen above the trees, to the right of the runway and its parallel taxiway. Control of aircraft movements in the terminal area is from an observation post above the " finger." Further buildings and hangars are positioned to the left of the illustration, close to the main road.

This development is the first stage of the Gatwick project, but apparently construction of further stages will await developments in air traffic. A second runway is envisaged, parallel to the first, and to the right of it in the heading illustration, together with extension of the terminal building and the construction of two further " fingers " radiating from the base of the existing one.

Design and Construction of Runway

The runway is 7000ft long and 150ft wide, and is flanked on each side by a shoulder 75ft wide, with a strength of about half that of the runway proper. The two shoulders have a pink surface colour, which contrasts with the runway. Details of this construction are shown in the schematic cross-section, which also shows the strip of compacted clay bordering each of the shoulders. This arrangement has allowed an economy in the width of full-strength runway construction. Another feature of the runway layout is the fast taxiway turn-offs (two for aircraft landing in the westerly direction and one easterly) which allow aircraft to make a high-speed taxi-ing turn at 50 or 60 m.p.h. on to the taxiway, thus clearing the runway more quickly and increasing its usage rate.

The heaviest aircraft, such as the new transatlantic jet machines, will be able to land on the runway on diversion after long flights, i.e. not at their fully laden weight. Runway design thus resolved itself into the form shown in the cross-sectional diagram, with a main load-bearing slab of high-strength unreinforced concrete 12in thick, laid on a base of lean concrete 4in thick. This base, in its turn, rested on clay formation, or where fill was needed, on a compacted clay base, using clay from elsewhere on the site, or on imported fill of compacted hoggin.

There are several points of special interest in this form of construction. First, emphasis was placed on reducing the frictional restraint between the main slab and the base, and hence achieving the structural behaviour envisaged in design. This was done by laying a polythene membrane between the two. The strength of the main slab at its joints is maintained by dowel bars which had to be positioned with great accuracy. The spacing of joints splits up the runway into 15ft squares ; a typical square, before the main slab was concreted, is shown in an accompanying illustration. The three principal types of joints are : (*a*) longitudinal contraction joints (at 15ft centres), a single dowelled joint, the top being sawn to a depth of 2in, and a filler board and filler compound inserted ; (*b*) transverse contraction joints. Reinforcing steel was placed across these joints, a " crack inducer " (i.e. an inverted V-shaped timber) placed at the bottom of the slab, and the top again sawn and filled ; (*c*) transverse expansion joints at 135ft centres. A detail of an expansion joint is shown in the drawing. The joint is " preformed," the strip of chip boarding being held in place by an abutment of concrete of the shape shown, which is incorporated in the main slab. All three joints are shown in the illustration referred to above.

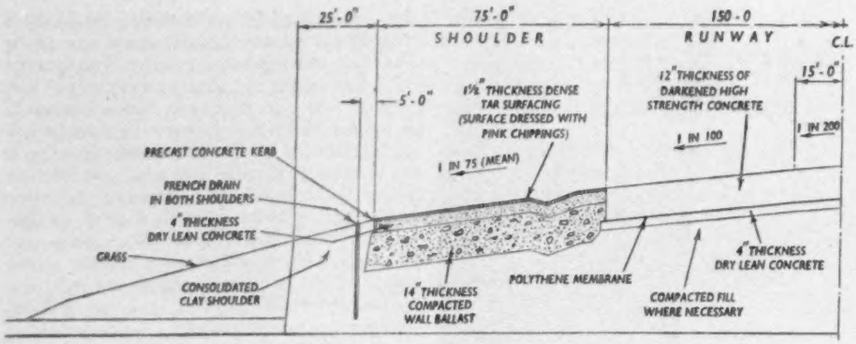
The concrete of the main slab was laid to somewhat exacting specifications, namely, a tolerance of $\frac{1}{4}$in in 10ft for surface irregularity and a minimum twenty-eight-day crushing strength of 5000 lb per square inch. The consultants point out that these two requirements were to some extent incompatible, but a satisfactory standard was achieved after " considerable experiment and research by the contractors." A train of plant used for concreting the Gatwick runway is shown in the illustrations on page 897. There are two finishing machines in the train and the scraping straight-edge is shown in use in one of the illustrations. Five such trains of plant were in use at the peak period of concreting, supplied from three concrete mixers with the expected weigh-batching equipment.

The concrete is also unusual in that carbon black was added to the mix, to darken the runway surface, and hence throw the runway markings into greater prominence and minimise glare. The polythene membranes also proved efficacious for curing, and were used on other concreting works on the site ; the top of the main slab was, of course, cured by spraying on a curing compound from a device at the rear of the concreting train.

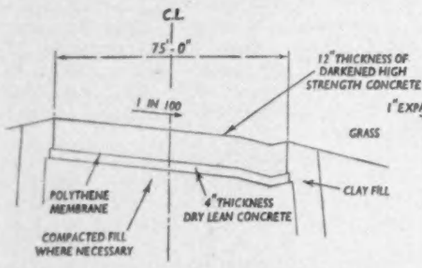
High rates of progress were achieved in constructing the runway. Preliminary works such as culverting the River Mole were undertaken in 1956, major earthworks being started early in 1957. Drainage works formed an unusually large part of the total work. Flow into the River Mole has been reduced from a design figure of 40 cusecs to 28 cusecs by constructing balancing ponds. Electrical ducting serving the runway was a further complication. Laying of the base course of dry lean concrete started in April, 1957, and construction of the shoulders—which have a dense tar surfacing with pink Newton Abbot chippings—in the summer of that year.

Terminal Buildings

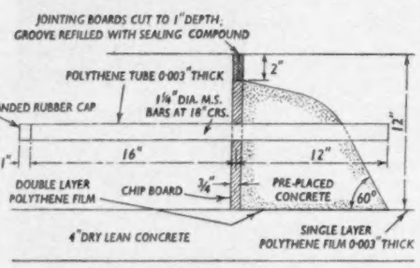
The terminal buildings are noteworthy for the prominence of the primary structure in their architectural treatment. The surfaces of concrete columns in the main hall, for instance, have been left with the board marks of the shutters untouched ; this " rough " treatment contrasts with a certain richness in the other architectural " finishes " of the hall. Again, the welded steel frames of the " finger " are exposed prominently, and the tubular steel trusses between them serve as handrails. In both cases this treatment gives clean lines to the buildings, and is very successful. The main hall spans the dual carriageways of the main road below it on



TYPICAL CROSS SECTION OF RUNWAY AND SHOULDERS.



TYPICAL CROSS SECTION OF TAXIWAY.



TRANSVERSE EXPANSION JOINT.

Diagrammatic cross section of runway and typical taxiway. The joint detail shows an expansion joint

heavy prestressed concrete beams. These beams are massive enough to carry a column system, independent of their own supporting columns. The ground floor of the "finger" is taken up by offices and services of various kinds, and passengers travel along corridors on the first floor, to and from their aircraft.

The Ministry of Transport and Civil Aviation's consulting engineers for Gatwick airport are Messrs. Frederick S. Snow and Partners. The main contractor for the civil engineering works was Sir Alfred McAlpine and Son, Ltd., for the terminal building the Turriff Construction Corporation, Ltd., and for the control tower Gilbert Ash, Ltd. The 2¾-mile diversion of the London–Brighton road and another road diversion were under the direction of the county engineer and surveyor of Surrey, the contractor being Tarmac Civil Engineering, Ltd. The new railway station was built for the Southern Region by James Longley and Co., Ltd. The architects for the airport were Messrs. Yorke, Rosenberg and Mardall.

Runway Lighting

The familiar Calvert approach lighting, the line and cross-bar system, first installed at London Airport and since internationally accepted, extends for 3000ft beyond the runway at each end. In good weather it shows a pattern of red lights, visible in all directions, along the extended centre line of the runway intersected by two cross bars. In poor visibility the pattern is changed to a line and five cross bars of much brighter white lights beamed to face the approaching aircraft.

Down either side of the runway the edge of the concrete is marked at 200ft intervals by a line of white lights visible in all directions. In poor visibility much brighter lights are brought into use directed to shine towards the aircraft as it makes its approach and landing. A line of green lights runs across each end of runway to mark the threshold, with a 75ft gap free of light in the middle. The location of the threshold is additionally emphasised by a "wingbar" of four green lights on either side; 1000ft down the runway from the threshold there are similar white "wingbar" lights of high intensity. The green and white "wingbars" assist the pilot coming in to land to judge the angle of descent in order to touch down between the two sets.

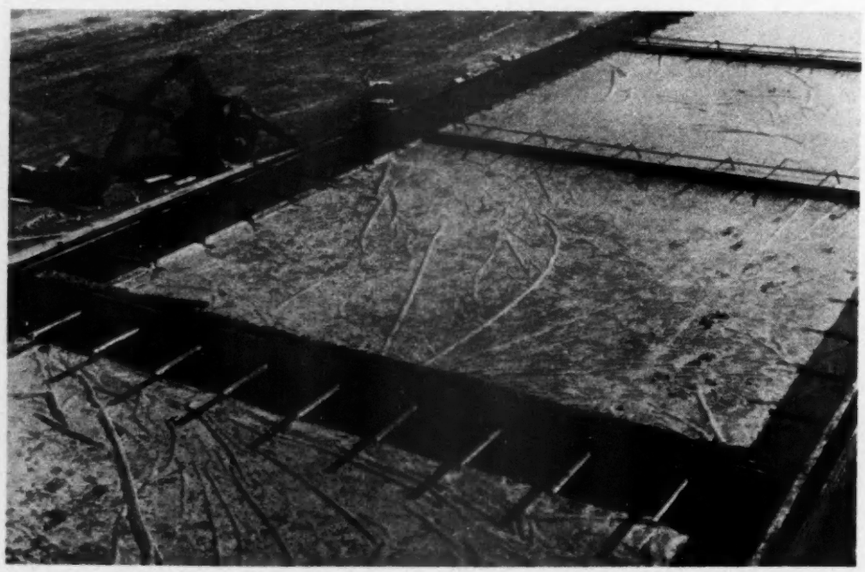
Although landings in low visibility are aided both by radio, radar and the special lighting described above, pilots have found that on nearing the threshold of the runway they seem to run into a pool of darkness when the guidance given by the cross-bar approach lights disappears beneath the nose of the aircraft. Brightening the runway lights may only make matters worse, particularly in mist or rain. As a result of full-scale experiments an entirely novel form of inset lighting has been installed on the runway itself at Gatwick for the first 3000ft. The runway is kept clear of all lights along a central strip 75ft wide corresponding with the gap in the threshold lights, but on either side short transverse bars of four lights set in the concrete of the runway at 250ft intervals, and thus flush with the runway surface, help to illuminate the touch-down zone.

Telecommunications

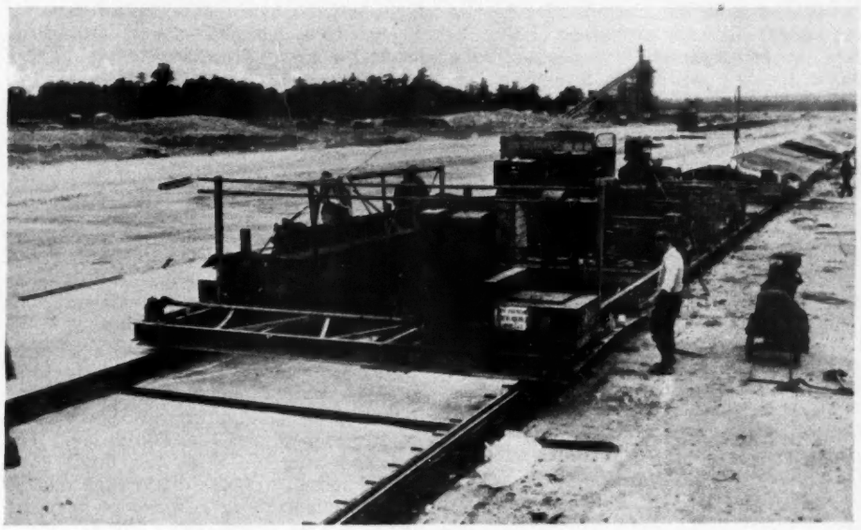
The airport's wide operational requirements demanded great variety in the telecommunication equipment. Three main aspects of the telecommunications organisation are described here. They are: (*a*) radio and radar navigational aids to aircraft; (*b*) radio communications facilities; (*c*) "fixed services," namely, the semi-automatic signals centre and the telephone facilities.

Radar Navigational Aid Facilities.—A standard Instrument Landing System comprising dual localiser, glidepath, middle and outer markers and compass locator beacon, has been installed on the basis of one complete installation for each landing direction. Normal remote control and monitoring facilities are provided. In addition, Precision Approach Radar has been installed, at present consisting of a mobile G.C.A. equipment with displays in the airfield vehicle. This is scheduled to be replaced later by a Precision Approach Radar consisting of a mobile aerial head with displays "remoted" to the approach control.

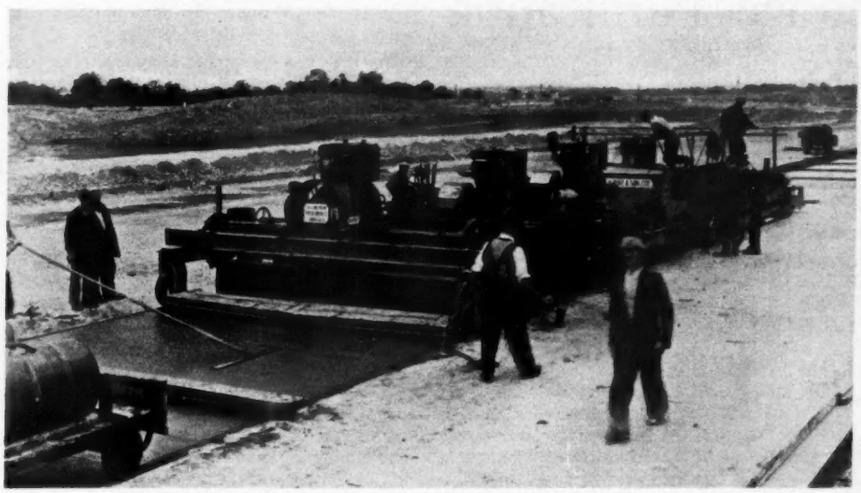
To ensure the maximum continuity of service, there are two completely separate surveillance radar systems, namely, the Cossor ACR Mark VI, and the Marconi S232 which, in conjunction with the P.A.R., provide a completed G.C.A. system. The ACR Mark VI is a high-power search radar operating on a wavelength of 10cm to provide short and medium-range cover on the approaches to the airport. Moving target indication (M.T.I.) is provided to eliminate permanent echo clutter from the radar displays. In addition, to reduce the returns from clouds and rain, circular polarisation is incorporated which discriminates in favour of the aircraft echo. The installation is in three parts, the aerial head, on a building to the west of the airport which houses the radar transmitter and receivers, terminal equipment in the telecommunications equipment room in the control tower (including the equipment to obtain the cancellation of permanent echoes) and, finally, the displays in the aerodrome and approach controls.



Section of main runway ready to receive the high-strength concrete of the main 12in slab. The three kinds of joints, the steel rails for the concreting plant, and the polythene membrane laid on the base concrete are all shown



Concreting the runway. The machines span 15ft and are travelling towards the camera. The train consists of a spreader, two finishers, a joint cutter, a sprayer for curing compound and covers



Concreting train from the rear. A scraping straight edge is shown in use, with part of the sprayer for curing compound visible on the left

provide Air Traffic Control with ACR Mark VI and/or S232 displays as required and so maintain the maximum continuity of service.

Radio Communications.—Radio communication at Gatwick follows the pattern of the installation at London Airport. The V.H.F. transmitters for the aeronautical speech channels, which have a power output of approximately 10W, are duplicated to provide a main and stand-by service for each channel. A " no-break " mains power supply ensures uninterrupted service in the event of a mains failure. A system of common aerial working, by which four transmitters operate into one aerial, is employed.

Remote control circuits from the transmitter and receiver station are split up by line termination equipment, so that they may be fed to a number of control points in such a manner that each control point is fed a satisfactory signal unaffected by the number of operators on the channel. Transmitting facilities are similarly arranged. The line termination equipment also provides " on-channel " inter-communication which enables operators using the same channel to intercommunicate without their speech being radiated.

Recording Equipment.—Gatwick airport will see the first installation of multi-channel magnetic tape recording equipment which the Ministry is introducing into service to replace the single channel embossed film recorder at present in use. This equipment, which will initially record seven channels on a single tape, is capable of expansion up to fifteen channels. The recording duration before tapes need to be changed is eight hours. A system of automatic monitoring provides that in the event of a failure or serious deterioration of the amplifying chain associated with any channel, a change-over of that channel to a spare channel with its own amplifying chain is effected. The recording equipment is duplicated and any other failure will result in a change-over to the stand-by equipment.

The Gatwick Semi-Automatic Signals Centre.—The growth of civil aviation, with its consequent increase in teleprinter message handling, induced the telecommunications directorate of the Ministry to conduct a critical examination of the civil aviation teleprinter network. It was decided that all signal centres should be equipped with semi-

The displays are " table top " displays, permitting rapid replacement of the complete unit. In addition, much of the electronic equipment normally associated with radar displays of this kind has been put in the equipment room again to simplify routine servicing. To assist in the control of aircraft in the " approach to land " phase, electronic " video mapping " marks key holding points and the approach to the two runways.

The Marconi S232 radar operates at a wavelength of 50cm and again gives surveillance radar cover at short and medium ranges and provides an alternative service to the ACR VI equipment. Moving target indication is provided, and at this longer wavelength little or no problem exists in respect of clutter from rain returns. The installation is similar to the ACR VI in that it consists of an aerial head mounted on a building housing the radar transmitters and receivers, terminal equipment, including cancellation circuits in the telecommunications equipment room in the control tower and outlets to the " table top " displays which are identical to those for the ACR Mark VI. The radar displays are mounted in a stand with two consoles, one above the other, to

Concrete aprons adjoining the " fingers " have space for about twenty aircraft. Note the welded steel portal frames of the " finger," with tubular steel beams acting as handrails. The observation post above it controls aircraft movements in the terminal area

automatic teleprinter message exchanges specifically designed to reduce manual handling to a minimum. The first centre to be equipped with a fully electronic, magnetic drum storage, "push button" teleprinter exchange is at Gatwick airport. The teleprinter exchange is known by the manufacturers as "STRAD" (signal transmitting receiving and distribution system).

The "STRAD" handles traffic between local airport extensions at Gatwick and several trunk routes to the national signal centre at Croydon, London Airport, and the cross-channel signal centre at Lympne. The equipment is expected to handle approximately 3000 messages daily, 10 per cent of which will pass through the centre in the busy hour. All messages arriving and leaving the centre are switched electronically, the magnetic drum forming a temporary store whilst switching operations are in progress and for holding messages until engaged lines are freed. The only intervention required by the operator at the exchange is to scan the message's address and press the appropriate buttons so that the electronic equipment routes the message. Messages begin to flow out of the system within seconds of being received.

By using electronic equipment for switching and teleprinters for delivery, manual handling and message delivery delays have been drastically reduced, with consequent staff savings. The manufacturers have designed the equipment so that at some future date even the manual routing function can be eliminated, and when the various international procedural problems are resolved, the way will be clear for the introduction of a fully automatic civil aviation teleprinter network.

It is also claimed that Gatwick has the most modern telephone and cable system to be used at any airport. A central private automatic telephone exchange handles the airport calls and there are direct lines to Livingstone exchange and London Airport. Air traffic controllers in the control tower are provided with a new design of "miniaturised" telephone keyboard.

Plant at Hoscar Sewage Purification Works

The sewage works serving Wigan has been extensively reconstructed. The works purifies by biological filtration, and some of the main plant and processes in sedimentation and filtration are briefly described. Heat from the cooling water of the dual-fuel engines is utilised for sludge digestion and a thermal efficiency of around 70 per cent can be obtained under favourable conditions.

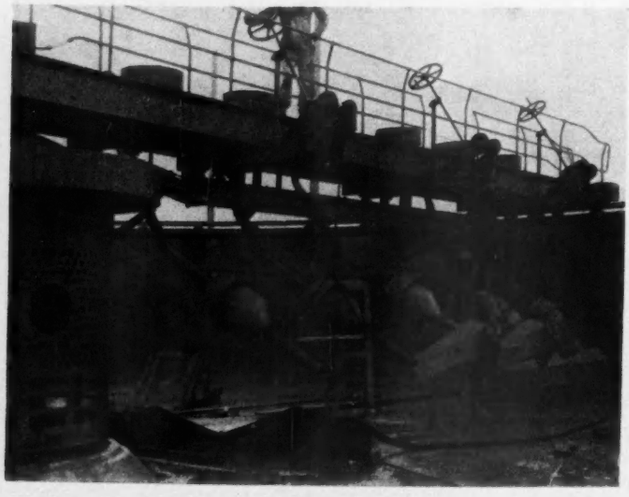
THE official opening is due to take place to-day of a reconstruction scheme at the sewage disposal works at Hoscar, in the valley of the River Douglas; this works serves the county borough of Wigan. The works presents several points of interest in its design and construction, although it has no radical departures from normal practice. Here we describe the works as a whole very briefly, and pick out one or two items of plant for more detailed treatment.

The storm water tanks serving Wigan are actually within the boundaries of the county borough, and a 7½-mile trunk sewer leads from them to the works at Hoscar. This works is now equipped to treat fully a flow of sewage of 5 m.g.d., this being the flow anticipated from a population of 105,000, plus 1 m.g.d. of trade effluent from a new canning factory. The heavy flow of trade effluent plus factors in the septicity of the sewage due to the nature of the trunk sewers, militated against the use of the activated sludge system. Further, detritus is removed and the sewage is screened at the storm water installation at Wigan, where up to three times the dry weather flow is diverted to Hoscar.

The new elements in the works, therefore, comprise the following: a pump-house with four 12in centrifugal pumps, to improve the hydraulic conditions in the trunk sewer, which functions as an inverted syphon; primary sedimentation in four 75ft diameter tanks; biological filtration in two new batteries of filters; final sedimentation tanks—two 75ft diameter radial flow tanks; sludge digestion in two digestion tanks; a power-house with dual-fuel engines. These new elements function in parallel with existing elements of the works.

Primary Settling Tanks

The primary tanks are of interest because of the method of sludge collection. Hopper-bottomed tanks would have been difficult to construct under the sub-soil conditions at the Hoscar site, so the tanks are flat-bottomed. Each one has a water depth of 9ft 2in and a capacity of 250,000 gallons, giving two hours' retention at maximum flow.



Preliminary settling tanks showing final erection of sludge scrapers and pumps

The peripheral wall of each tank is surmounted by the usual overflow weir and collecting channel. An inlet pipe conveys the incoming liquor to the centre of the tank, where a vertical bend discharges into a steel drum, the lower chamber of which is perforated to diffuse the liquor evenly throughout the tank. The upper part of the steel drum is plain and separated by a conical steel plate to form a sludge well.

Spanning the tank radially is a rotating bridge, carried above the centre drum by a heavy-duty, combined thrust and journal, taper roller bearing. The outer end of the bridge is carried by track wheels running on a rail track round the peripheral wall. The drive is by a small motor through reduction gearing to one of the outer track wheels.

From the bridge is suspended a series of vee-shaped sludge scrapers, which form together a continuous zig-zag across the radius of the tank. They are shown under construction in the first illustration. The liquor leaving the dispersion drum flows evenly and at a rapidly diminishing velocity to the peripheral weir, the sludge falling to the flat floor of the tank. As the bridge rotates slowly, the settled sludge is collected in the vee-shaped scrapers. A submersible pump, the "Pneu" pump, is arranged above each vee scraper, the inlet pipe being taken into the angle of the vee and the delivery pipe rising to discharge into a collecting channel along the rotating bridge.

The "Pneu" pump is a very simple device, as the accompanying diagram shows. The only moving part is the inlet valve—a ball valve in the case of the pumps at Hoscar. Sludge enters the pump chamber through the valve, the delivery pipe being open to atmosphere; eventually the seal pipe is filled, thus closing the chamber, and the compressed air supply then builds up a pressure and so ejects the contents of the vessel. As it empties, the seal pipe opens and exhausts compressed air through the delivery pipe, clearing it of liquid. The pressure is thus relieved and the pump can refill for the next cycle. A small air compressor on the rotating bridge supplies the battery of pumps in each tank. The air supplied, and hence the volume of sludge withdrawn, is regulated. The sludge is discharged by gravity to three consolidation tanks, each holding half a day's production. The "Pneu" pumps and the priming tank equipment generally were supplied by Ames Crosta Mills and Co., Ltd.

Filtration

The filter system—two new filter batteries and two similar existing batteries converted with new piping—is noteworthy for provision for either recirculation or alternate double filtration for flows up to twice dry weather flow. The maximum rate of filtration will then be 530 gallons per cubic yard of media per day. Straight filtration at 3×d.w.f. is envisaged, the rate being 315 gallons per cubic yard per day.

Devices have been installed in the filter beds for collecting samples of effluent at 12in and 36in depths below the surface, and for examining the media throughout the depth of the filter.

Dual-Fuel Engines and Sludge Digestion

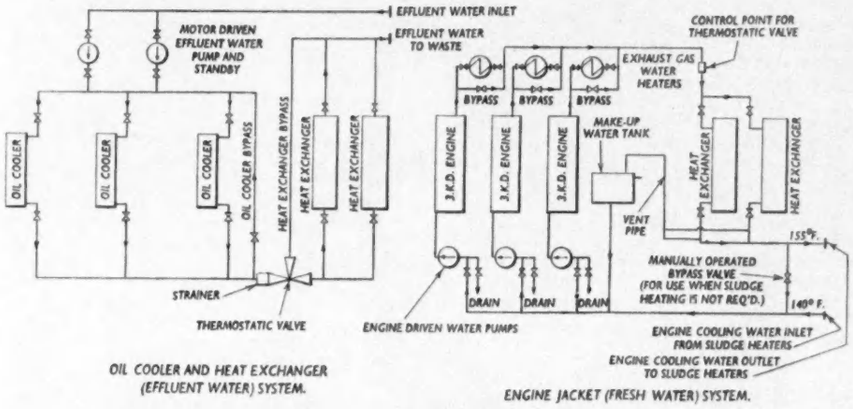
The cooling water circuits for the engines in the power-house, and the heating of the sludge in the digestion tanks, afford an instructive example of energy conservation. The system is shown diagrammatically in one of the illustrations, but before explaining it one or two more general facts should be given. There are three dual-fuel engines in the power-house, supplied by the English Electric Company, Ltd., with provision for a fourth. Each one develops 165 b.h.p. at 600 r.p.m. and drives an alternator with a continuous output of 112kW at 0·8 p.f., 400V, three-phase, 50 c/s. The gas generated by sludge digestion has an approximate calorific value of 625 B.Th.U. per cubic foot; changeover to or from diesel to dual-fuel operation can be effected on load.

Sludge is digested in two Prüss tanks, 60ft in diameter, which utilise a system whereby some of the sludge is extracted from the tank, heated, and then returned and mixed with the rest. This equipment also was supplied by Ames Crosta Mills and Co., Ltd. The interest of its application at Hoscar is that waste heat from the engines is used in the sludge heaters.

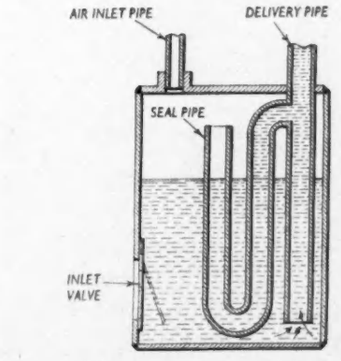
Considering the right-hand diagram of the above illustration, cooling water leaving each dual-fuel engine at around 140 deg. Fah. is passed through an exhaust-gas water heater. Thus the exit temperature of the engine cooling water is raised by 10 deg. or so by utilising some of the heat in the engine exhaust. These heaters can be by-passed if necessary.

The heat exchangers shown in this diagram come into play if the full range of temperature necessary in the cooling water circuit is not achieved by heat transfer in the sludge heaters. For instance, in the summer, less heat is needed for sludge digestion (the tanks are maintained at 85 deg. Fah.), but full power load may be needed. The left-hand diagram shows the other circuit of the heat exchangers. Thus, the engine cooling water may be cooled in the heat exchangers by circulating effluent water from the works. Normally, however, when heat from the cooling water is fully utilised for sludge heating, these heat exchangers will not be operative. Balance of heat exchange is obtained by thermostatic control, which brings in the heat exchangers if the cooling water gets too hot.

With the three engines on load, heat can be supplied to the sludge at about 600,000 B.Th.U. per hour. With good lagging, it is estimated that under these conditions an overall thermal efficiency of some 70 per cent is obtainable.



Schematic of heat transfer system for diesel engine water cooling and sludge heating



Diagrammatic representation of "Pneu" pump. Its operation is explained in the text

Centrifugal Ventilating Fans

The first stage of a works reconstruction and modernisation programme which has been completed by the Midland Heating and Ventilation Company, Ltd., Bedford Road, Birmingham, 11, has added some 10,000 square feet to the productive floor area in a new three-storey building. The additional space has been allocated mainly to the section of the works concerned with the manufacture of blades and impellers for the firm's "Gyra-flo Airfoil" centrifugal fans. As part of the overall development plan the section making the blades and impellers has been retooled and new equipment installed to facilitate and speed production of the standard sizes in greatest demand. Fans are now being made in a range of sizes capable of handling from 440 to 650,000 cubic feet of air per minute when arranged for single inlets, and up to 1,200,000 cubic feet of air per minute when fitted with double inlets and double width impellers.

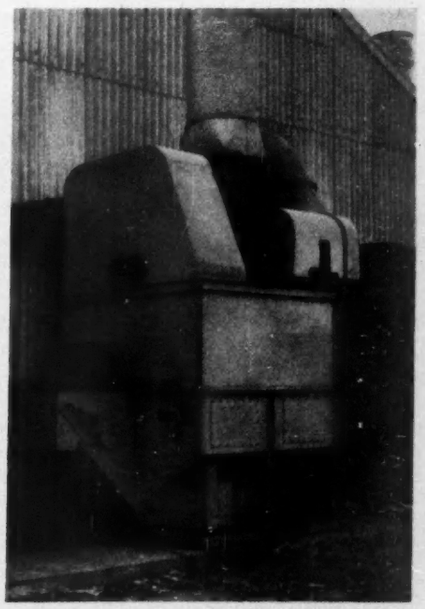
The design of the impellers used in "Gyra-Flo" fans can be seen in the illustration of a sectioned unit which we reproduce. The aerofoil shaped blades of mild steel are welded at their roots to a rigid back plate locked on the main driving shaft. At their tips the blades used in the very large and high-pressure duty fans are strengthened by welded internal ribs, and this form of impeller construction provides an assembly of sufficient strength to eliminate need for bracings or stiffening rings.

A fan housing of welded steel plate incorporates a spun steel inlet cone, and the fans can be supplied for either clockwise or anti-clockwise rotation with any of eight standard forms of housings having alternative air discharge angles. The driving unit pedestal at the side of the fan housing is available with ball, roller or sleeve bearings, and any of four alternative forms of drive either with directly coupled motors or pulleys can be supplied. When hot air is to be handled a cooling disc is fitted on the drive shaft between the inboard bearing and the impeller to dissipate the heat; alternatively, water cooled bearings or shafts can be fitted.

These fans are stated to have a very low noise level during operation and it is claimed that efficiencies of more than 70 per cent are maintained over 55 per cent of the operating range whilst maximum efficiencies of over 90 per cent are obtained, and power consumption is relatively low.

Impeller of centrifugal fan, showing construction of aerofoil blade

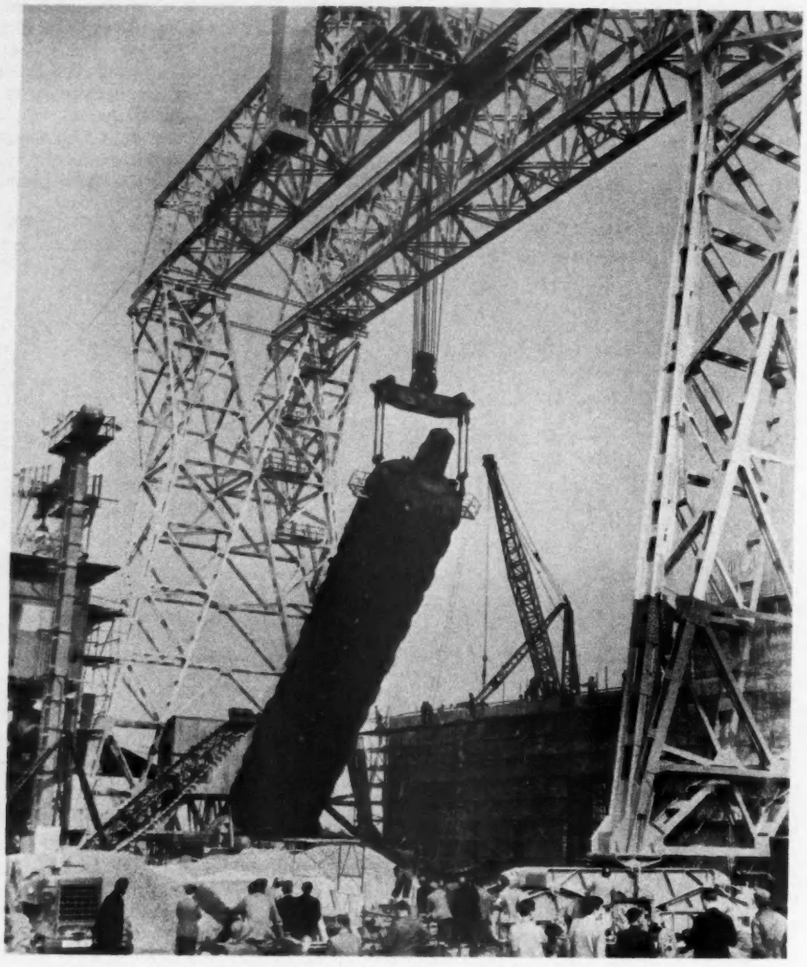
The second illustration shows a typical ventilating installation of one of the firm's "Size 27" fans which is operating in conjunction with a "Midac" wet dust arrester. This fan has a 29¼in diameter impeller absorbing 36.6 b.h.p. when running at 2167 r.p.m. and it is designed to handle 14,500 cubic feet of air a minute against a resistance of 13in w.g. It has a 29¼in diameter inlet and a 26½in by 23½in outlet. This particular size of fan is made to cover a similar wide delivery range to the other fans made by the firm. When driven at 306 r.p.m. with a power absorption of 0·10 h.p. it delivers 2135 cubic feet per minute against a pressure of ¼in w.g. At the other end of the range when fitted for a 72 b.h.p. drive at 2710 r.p.m. it delivers 21,350 cubic feet per minute against a resistance of 16in w.g.

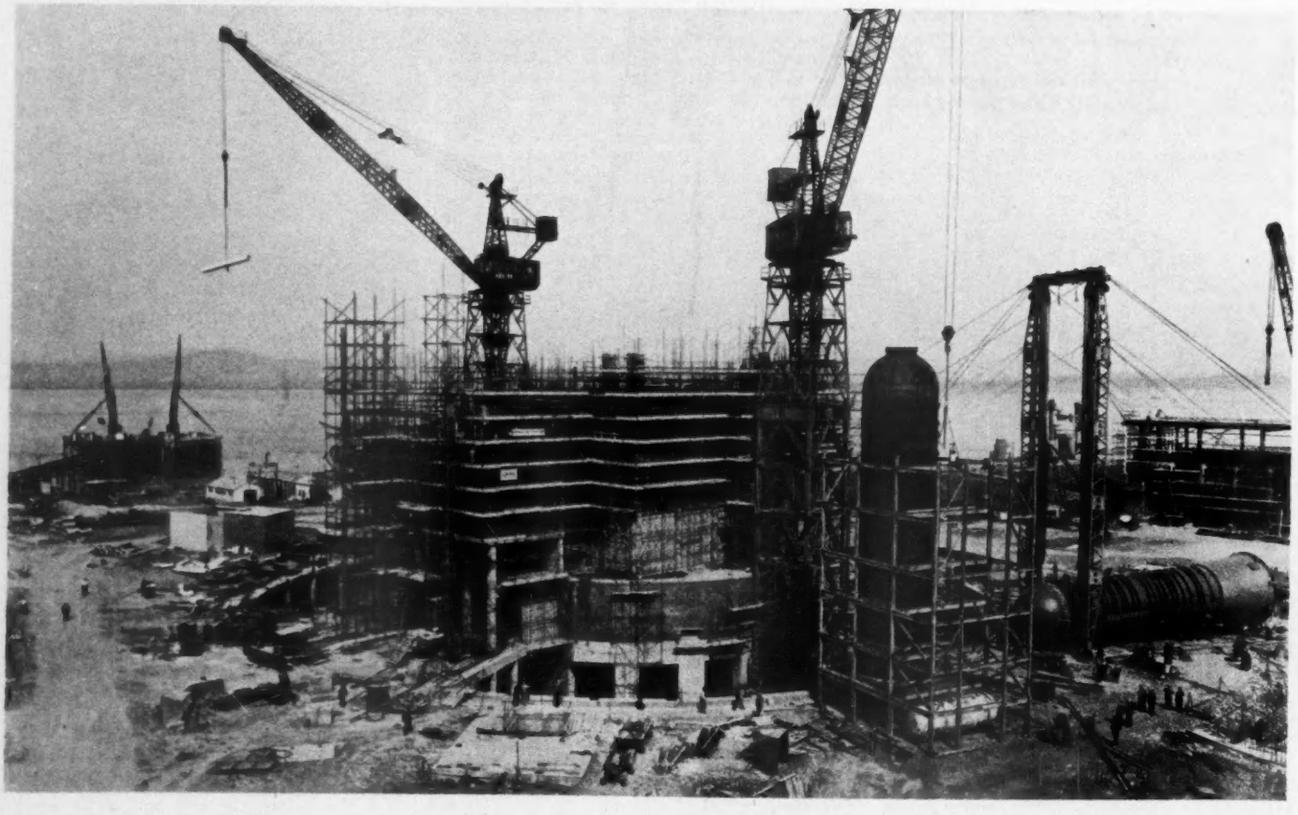


Ventilating equipment incorporating "Gyra-flo 27" fan and "Midac" wet dust arrester

Boilers for Nuclear Power Stations

Construction on both Berkeley and Bradwell nuclear power stations began almost simultaneously (in January, 1957), and to the superficial gaze progress on both sites is about equal at present. Although each station is a variation on the now well-known theme of Calder Hall, there are marked differences in interpretation, not only in the principles of design, but also those of construction. Thus, Berkeley is to employ cylindric pressure vessels for its reactors, while Bradwell will use spheres. Each design team staunchly maintains that its choice was the better one, and each intends to adopt the same form of pressure vessel in future designs. Clearly, only time will show whether one or another truly shows any advantage. Time will also show whether the A.E.I.-John Thompson Nuclear Energy Company, Ltd. (building Berkeley), or the Nuclear Power Plant Company, Ltd. (building Bradwell), has chosen the more successful technique of construction; the former uses monotower cranes and gin poles, the latter has erected a "Goliath" crane. Our pictures show the contrast between the methods of lifting the heat exchanger vessels on the two sites. The first of the sixteen heat exchanger shells was erected at Berkeley recently, and the event was described on page 780 of "The Engineer" for May 23. The LOWER ILLUSTRATION on this page shows the second boiler shell waiting to be raised alongside No. 1 reactor. These vessels are 70ft long, 17½ft in diameter, and weigh 133 tons apiece. They are welded on site from rings brought by road from John Thompson's works in Wolverhampton. The completed shells are moved on bogies from the welding shop to their places of erection. The boiler shells for Bradwell, on the other hand, are brought down by sea from Head Wrightson's works at Thornaby-on-Tees, towed by tugs, and we published an illustrated account of the launch and recovery of the first one in our issue of May 23 (pages 772-773). The photograph reproduced, RIGHT, was taken on June 4, when this first of twelve heat exchangers was lifted into position by the "Goliath" crane. The vessel is over 92ft long, 19ft in diameter for the greater part of its length, and 20ft in diameter at the base; it weighs 200 tons. The "Goliath" crane was described in our issue of March 28, page 473.





SHORTER REPORTS

Anniversary Celebrations

FAWCETT PRESTON AND CO., LTD.

THIS year marks the 200th anniversary of the founding of the firm, now known as Fawcett Preston and Co., Ltd., in York Street, Liverpool. The bicentenary of the company has been celebrated by a varied programme of events. On Wednesday of last week, an exhibition " Fawcett, Past and Present," was opened ; it includes old documents and drawings of considerable historical interest ; models of guns and early ships engined by the company, and photographs depicting past and present products such as pumping engines, sugar plant and baling presses. Over 250 guests representing industry, overseas Governments, and local government attended a luncheon, on Thursday of last week, at which the Lord Mayor of Liverpool proposed the toast of " Fawcett Preston and Co." Sir Charles Westlake, the chairman of the company, replied, and gave the toast of " The Guests," to which Mr. H. Oakshott responded. Two presentations were made at the luncheon ; Mr. Leslie Davies, the managing director of the company, presented a silver salver, suitably engraved with scenes from the history of " Fawcett's," to the Mayor of Bebington. The second presentation was made by Sir John Hathorn Hall, a director of the Peninsular and Oriental Steam Navigation Company, who handed to " Fawcett's " a painting of the paddle steamer " William Fawcett," which had engines built by William Fawcett and was the first steamer owned by the Peninsular Company. A commemorative plaque has also been placed at the site of the original factory in Liverpool.

Apart from the social and other events, the attainment of the bicentenary has been more permanently set out in a book by Horace White, having the phonetic title of *Fossets*, which is a record of the two centuries of engineering of Fawcett Preston and Co., Ltd. The book spans the history of British engineering and opens with the beginning of the company by the establishment, in 1758, of a warehouse and a foundry, known later as the Phœnix Foundry, at York Street, Liverpool, in charge of George Perry. A turning point in the affairs of the company came with the advent of William Fawcett in 1784, who remained in control for sixty years, during which the scope of the business expanded, particularly under the stimulus given by the adoption of steam as a source of motive power. Steam engines were exported to the sugar plantations and adapted for ship propulsion, the Mersey ferry " Etna " (1817), being the forerunner of a long line of notable vessels. These include the first P. and O. steamship the " William Fawcett " (1828), an illustration of which forms part of the decoration of the observation lounge of the P. and O. liner " Arcadia " ; the " William Tell " (1822), the first steamer on Lake Geneva ; the Royal " William " (1837), the first steamer on the Liverpool to New York service ; the Confederate commerce raider " Florida " ; trawlers in the first world war, and frigates in World War II.

The book recalls that the third of the men who were the driving force behind the company was Alfred Chapman, who travelled all over the world installing sugar machinery, ice plants and sea water distillation apparatus, and who directed the company from 1888. A wide variety of tailor-made machinery continued to be manufactured during these years and new ventures outside the profitable lines of presses and sugar machinery included pithead gear, compressors, pumping engines, and even a steam car. Life and conditions in the works during the last quarter of the nineteenth century, at the turn of the century and after the first world war, are pictured from the diaries and reminiscences of three apprentices and brings to a close the firm's association with Liverpool, lasting some 177 years. In 1935, the factory was moved to Bromborough, on the south side of the Mersey, and since that date the floor area has been increased to 135,000 square feet and the shops re-equipped with modern machinery. During its existence the company had weathered many storms, and in 1947 was in difficulties again, difficulties which were resolved by becoming a member of the Metal Industries Group, but with its own identity preserved. To-day, the company remains, as it always has been, one of general engineers, and produces baling presses for cotton, jute and wool, and a host of other materials, including man-made fibres ; deep drawing presses, band presses, electrical resistors and machinery for the rubber and plastics industries. This history of 200 years of engineering is excellently illustrated with old prints, drawings, Press announcements, and the end papers are reproduced from Fawcetts' earliest engine book.

D. NAPIER AND SON, LTD.

To celebrate its 150th anniversary, D. Napier and Son, Ltd., is holding an exhibition at the Tea Centre, Regent Street, London. This exhibition, which closes tomorrow, effectively indicates the breadth of the firm's engineering activities from its early years, when David Napier manufactured printing presses, right up to the present time when its products include such engines as the " Deltic."

David Napier, who founded the business, came to London from Scotland in 1808 and for the first ten years or so carried out general engineering work. In 1820, he was commissioned to build a printing machine to an American design. This order led Napier to make a study of printing machinery and ultimately he produced platen presses of his own design. His subsequent enterprises in the early years of the business included the building of a bullet-making machine, with an output of 25,000 bullets a day, which was installed at Woolwich Arsenal, and other equipment for ordnance factories, such as cranes and a steam-driven, gun-finishing machine. There were also gold coin weighing machines, hydraulic equipment for the building of the Great Western Railway, and machines for registering the weight of stone.

The founder of the business retired in 1866 and was succeeded by his son, James Murdoch Napier. J. M. Napier has been described as a " brilliant and imaginative engineer," but one who lacked a "sense of business." This lack of business acumen evidently led to some decline in Napier activity which persisted until the business was acquired, in 1895, by Montague Stanley Napier, who was J. M. Napier's youngest son. He, like his predecessors, showed considerable inventive ability, and, soon after taking over the family business, designed the first Napier motor-car engine which was a two-cylinder, four-stroke of about 8 h.p. M. S. Napier was a member of the Bath Road Club. One of his fellow-members, S. F. Edge, became interested in cars and formed an agency in London. He undertook to sell all the cars that Napier could make ; in the first four years or so of the present century this agency disposed of 396 Napier cars.

In addition, the Napier works turned out many hundreds of taxi-cabs and commercial vehicles, and in the early months of the first world war began to build lorries and ambulances for the British and Allied Governments. But, of course, the demand for aircraft and aero-engines soon became insistent. In 1916, M. S. Napier offered to produce an aero-engine at his own expense ; the result was the twelve-cylinder " Lion," designed by A. J. Rowledge, which appeared in 1918 in time to be used in the final stages of the war. The development of aero-engines continued between the wars and by 1938 the " Sabre " was in production.

M. S. Napier, who died in 1931, was the last member of the family to participate in the business founded by his grandfather. In 1942, D. Napier and Son, Ltd., became a member of the English Electric group of companies, and in the post-war years has included gas turbine and rocket motor development in its activities. The " Deltic " diesel engine is another Napier achievement. Examples of most of these modern products have a place in the 150th anniversary exhibition. Alongside them is an excellent model of David Napier's double platen printing machine, and a replica of one of M. S. Napier's inventions. This is a pair of skates for fast, long-distance runs ; each skate has two wheels similar in size to the front wheels of a modern perambulator !

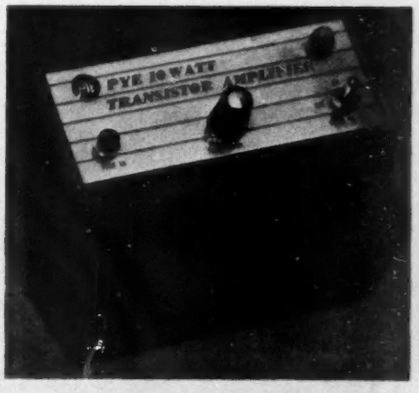
Use of Sea-Water in Guernsey

IT has been announced by the State of Guernsey that its Water Board is to construct a plant for evaporating sea-water for use in supplementing normal water supplies. Provisional tenders have been received from G. and J. Weir, Ltd., and from Richardsons Westgarth and Co., Ltd. They cover supply and erection of a flash evaporator with a daily output of 500,000 gallons, and a boiler and steam turbine generating set of about 2·3MW capacity. The cost is stated to be about £350,000.

It is anticipated that the plant will be in use in about eighteen months' time, the yield of 0·5 m.g.d. being about 20 per cent of the present total consumption. Water supplies on the island have been strained for some time, largely due to increases in the intensive cultivation of tomatoes under glass. Well-water supplies have been extensively developed, and construction of a conventional reservoir, to tide over a drought, would have cost more than £800,000, it was stated.

Transistor Amplifier

THE accompanying illustration shows a portable, battery-operated transistor amplifier which weights 5½ lb, has an output of 10W, and is made by Pye Telecommunications, Ltd., Newmarket Road, Cambridge. It is independent of electricity mains, the power requirement being supplied by



10W portable transistor amplifier, powered by 12V dry battery or accumulator

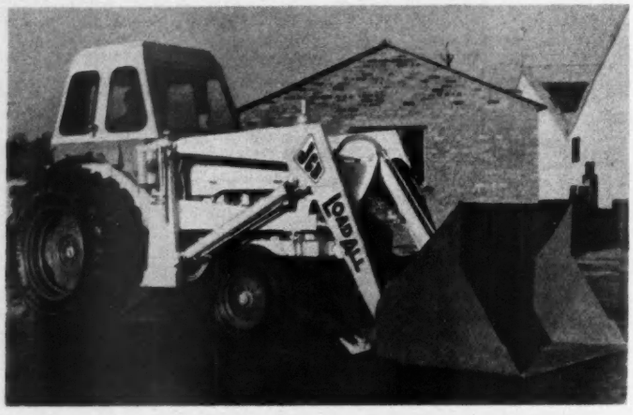
a 12V dry battery or accumulator. The use of transistors reduces the current consumption by about 80 per cent and at 10W the current drain is only about 1·8A. The dimensions of the case are 8in by 3½in by 6in. The only controls are an " On, Off, Press to Talk " switch, and a gain control knob.

Hydraulically Operated Loading Shovel

ONE of the excavating machines which can be seen at the building plant exhibition which is open from 11th to 18th of this month in Birmingham, is a loading shovel known as the "Loadall," made by J. C. Bamford (Excavators), Ltd., of Uttoxeter. This machine is new, and incorporates several improvements over the firm's previous designs, including a power crowd; it is shown in the illustration.

The "Loadall" consists of the following elements: a subframe of welded pressed steel formed into hollow box-shaped elements, and pinned to the tractor; the two arms, also of boxed welded pressed steel; the bucket with the scarifier; and the hydraulic system with two rams for the arms and one for the crowd action and tipping of the bucket. Four pins hold the subframe to the tractor chassis; two at the front are arranged parallel to the centre line of the tractor so that they transmit vertical load only, and two at the back, bearing on to a strong rear bracket, are at right angles to the centre line and transmit the thrust from the loader to the rear bracket.

Hydraulic fluid is contained in the subframe, which has large cooling surfaces. The system is operated by a gear pump of 25 gallons per minute capacity. The rams are of 3½in bore, with 2½in shafts. The bucket can be of ¾, ⅞ or 1¼ cubic yards capacity; as the tractor reverses, the scarifier mounted behind the bucket is pressed down by the rams, and so loosens the material to be loaded. A bulldozer blade, 84in wide, and a crane attachment lifting 15 cwt, may be used with the machine. With the bucket loader as described, material can be loaded over a height of 11ft, and the machine has a forward reach of 3ft 6in. The forward digging load imposed by the machine is about 5200 lb, plus about 1800 lb due to the crowd.



Hydraulically operated loading shovel

Another of the same firm's products is also to be seen at the Birmingham exhibition, namely, the "Hydra-Digga." It consists essentially of an A-frame, mounted transversely behind the rear wheels of a tractor such as the one illustrated. The frame extends to about twice the width of the tractor's wheelbase, in a shallow A-shape, and is pushed downwards by a hydraulic ram, so that the tractor's rear wheels are clear of the ground, thus giving stability for excavation. A half-circle excavating jib and bucket, controlled by hydraulic rams, is mounted on the A-frame. The bucket may be up to 9 cubic feet in capacity. Excavation can proceed from one set up to a depth of 13ft (and to a loading height 10ft 8in) with a face-shovel rig, and to 16ft (with corresponding reach and discharge height of 21ft and 13ft 6in, respectively) with a back-acter rig. For digging narrow trenches, a taper ejector bucket may be used. The narrowest of these buckets has a width of 8in, tapering to 12in; the output rate for a bucket of this kind, digging a trench 2ft 6in deep, is stated to be 2½ to 3 chains per hour.

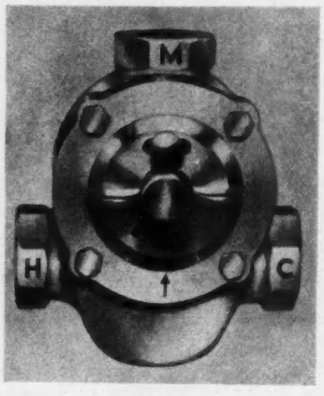
Coated Macadam Plant at Hayes

A PLANT for producing all forms of coated macadam, cold asphalt and water-based macadam has recently been completed by Crow, Catchpole and Co., Ltd., at Hayes, in Middlesex. The plant has a large capacity and two 60 cubic foot double-paddle mixers are installed. This mixer installation and its control is in fact almost identical* with the one described in our issue of April 18 last, as part of the article, "Slag Production Plant at Teesport," and it exemplifies present-day trends towards close control in the production of "black top" road materials. Apart from the mixer, house, the installation at Hayes consists of a wagon tippler (crushed stone is delivered by rail), a stockyard, two rotary dryers, and twin sets of screens and storage bins for up to 2000 tons of dried and screened sizes. The plant is noteworthy for this duplication of screened storage, which allows either limestone or slag to be used in the various mixes. The coated mixtures are delivered by road; normally, delivery schedules give a "peak" period in the early morning, and so the storage plant has been devised to deliver batches of material rapidly to the mixer plant. Belt speeds have been increased (batches are proportioned by "graders" at the hopper outlets, and there is a minimum time delay of only twelve and a half seconds between the "strips" of 3-ton batches on the batching conveyor. The order of depositing the various sizes of materials on the belt has been rearranged to give the quickest delivery. Limestone aggregate travels furthest along the belt and if both aggregates are needed, automatic selection gives the best time schedule for co-ordinating the two. The maximum potential output from one mixer, working on one specification, is about 120 tons per hour. Reference to our earlier article will explain equally the functions of the plant at Hayes.

* Provision for handling the binders is slightly more elaborate, there being a choice from six storage tanks.

Water Temperature Controller

A RANGE of mixing valves for use in hot water central heating is being made by Sigmund Pumps, Ltd., Team Valley, Gateshead-on-Tyne. This type of controller is designed to keep system temperatures at a preset comfortable level without opening and closing of individual radiators, whilst the hot water supply for domestic use can be maintained at the required higher temperature. For its use, the central heating system is provided with a boiler by-pass between flow and return, so that some of the cooler return water can be blended with the hot water from the boiler and recirculated to maintain a fixed temperature.



Mixing-valve temperature-controller for hot water central heating systems

The "Sigmix" controller, as it is known, is set to give the flow temperature required in the heating system usually between 95 deg. and 194 deg. Fah., depending on the type of installation, weather conditions and the requirements of the occupants. This flow temperature can be varied instantly by adjusting the dial or handle of the instrument.

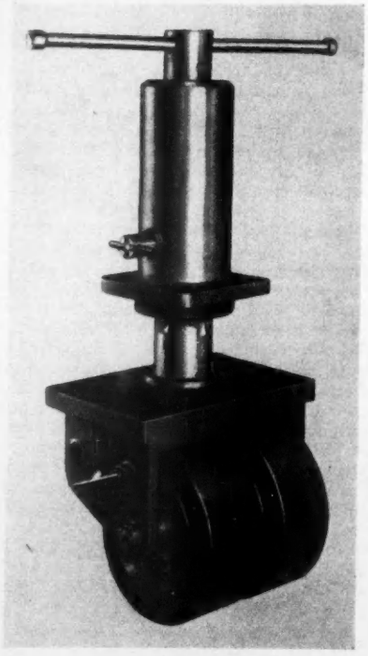
In these valves, one of which is illustrated below, a bi-metal spiral in the upper part of the casing transmits the control movement to a double clack in the lower part. This movement either opens the inlet port from the boiler and closes the return port from the heating system, or vice versa, so that a mixed flow temperature can be selected and maintained.

The controller is manufactured in ¾in, 1in, 1¼in, 2in, 2½in and 3in sizes, so that suitable valves are available for all types of domestic, public building and industrial heating installations.

Jacking Castor

WE illustrate a jacking castor which has been developed by Flexello Castors and Wheels, Ltd., Bath Road, Slough, Bucks, to meet certain requirements in the aircraft industry. This castor, which has an overall height of 40in, has a jacking movement of 3in and a lifting capacity of 3 to 4 tons. The castor itself has a free swivelling action which is quite independent of the jacking action.

The castor, of welded steel construction, is fitted with 12in diameter, 5in wide rubber-tyred twin wheels running on Timken tapered roller bearings. A wheel locking device on each side plate is operated by a hand screw, and a barring hole in the side plates can be used to assist turning of the castor for steering. The castor swivels on tapered roller bearings and bronze bushes in the body. The jacking operation is effected by a screwed shaft which turns in a bronze nut, the load being supported through roller bearings and bronze bushes. A spring-loaded locking plug in the body registers in four slots in the main castor shaft and can be used to fix the direction of the castor wheels when required.



Jacking castor with a lift of 3in and a capacity of 3 to 4 tons

Motor Vehicle Tyre Stores

A NUMBER of problems in control, handling and space usage are presented in providing an efficient storage system for the very large numbers of tyres and wheels of different sizes made by the Dunlop Rubber Company, Ltd., and an extensive stores modernisation and reorganisation scheme has been carried out recently, both at Fort Dunlop and the group of factories at Foleshill, Coventry. The stores section at Fort Dunlop is organised to receive motor vehicle tyres in batches of mixed sizes from the production departments, sort and store them, and prepare them for despatch in both large and small batches to users and agents at home and overseas. The stores at Foleshill is mainly concerned with tyres other than those for motor-cars such as are fitted on wheelbarrows, aircraft, earth-moving equipment and tractors. It is also responsible for handling the vehicle wheels and cycle wheel rims made in the adjoining factories, and the running of a large section concerned with the fitting of tyres to tractors and other heavy vehicle wheels. The reorganisation scheme developed for the two factories has, we are informed, simplified stores control, speeded handling and effected an appreciable saving in manpower.

Under the previous system, which was used for many years at Fort Dunlop, motor-car tyres were stored in tubular steel racking of conventional design in an eight-storey building. From this building the tyres were issued according to demand, and the basic arrangement of the stores on eight floors frequently necessitated complicated routing between floors to maintain the required speed of intake and despatch. Further, its capacity had become insufficient and overflow or " transit " stores had to be maintained in a number of other towns in the region, which further complicated control and involved additional manpower. The introduction of the new stores at Fort Dunlop has enabled all but two of these transit stores to be shut down. The new stores is situated in what is known as " B " block, a single-storey building which has a total floor area of some 221,000 square feet and of sufficient height to enable multi-tier pallet storage.

An important part of the reorganisation scheme has been the introduction of a special standardised design of tubular steel pallet for transporting and storing tyres and wheels in bulk, and which is readily adaptable by simple fittings to take all current sizes and types. The general design of the new tubular post pallets can be seen in one of our illustrations. They are of welded tube and section construction and are made 6ft long by 4ft wide in two standard heights of 5ft 4in and 6ft 4in. Grids which can be quickly and easily fitted into the main pallet frames adapt them to accommodate the numerous sizes of tyres and wheels to ensure the use of their maximum capacity. Fork lift trucks are used to stack the pallets in heights up to some 20ft at Fort Dunlop and 18ft at Coventry.

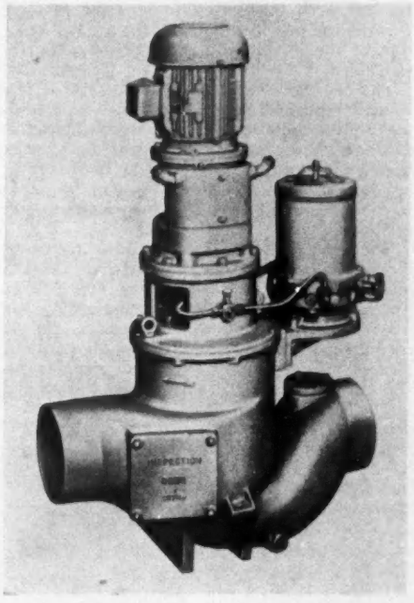
Under the handling procedure at Fort Dunlop assorted tyres straight off the production lines are loaded from a works outgoing conveyor system into trailer vehicles and delivered to the stores intake and sorting station shown in the accompanying illustration. At this station four gravity roller conveyors are wheeled up to the vehicle platform and the unloader places the selected tyre sizes on the appropriate conveyors. Men at the foot of the conveyors do the secondary sorting operation and, according to the number of sizes in the load, either stack the tyres as shown in the illustration or load them straight into pallets for delivery to the pallet storage blocks. The pallets follow a strict rotation through the store blocks so that the first one in is the first one removed for delivery to the despatch area at the far end of the stores. To ensure this rotation is followed each pallet leaving the reception area has a numbered sleeve placed on one of its posts, and this number registered on the stock control sheets identifies the load up to the time the pallet is completely emptied.

At the Coventry works a new stores building covering an area of some 223,000 square feet has been built and it is organised on similar lines for pallet storage without the use of fixed racks, to provide complete flexibility and a smooth flow in accordance with production and despatch requirements. As already mentioned, this stores is also responsible for the fitting of tyres to wheels, and when in full operation is capable of delivering some 10,000 fitted wheels a week for tractors and other heavy vehicles.

Small Comminutor

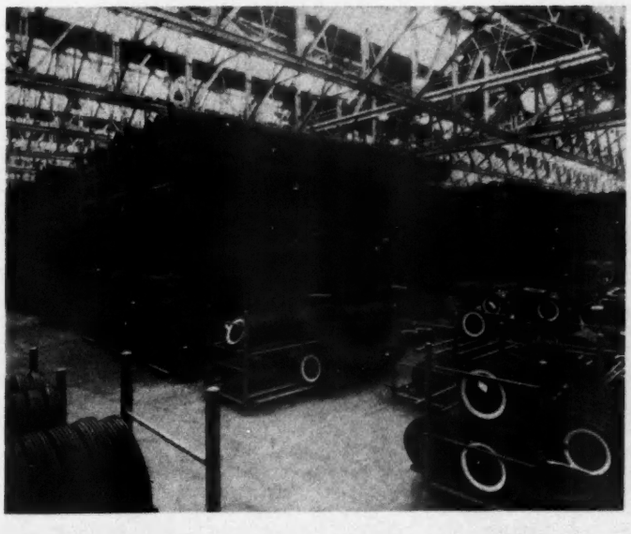
AN improved model has been introduced of the smallest capacity comminutor, made by Jones and Attwood, Ltd., of Stourbridge. These machines are designed for use in systems of fluids carrying solids in suspension, such as in sewage works, and they serve to cut up the solids into small particles, without need for their removal from the fluid system. Each machine consists essentially of a rotating drum which is slotted to form a screen through which permissible size particles can pass freely with fluid to a central outlet. A series of cutter bars and cutter teeth, spaced at intervals round the drum, co-operates with a line of cutter combs fixed down one side of the drum support housing. Thus, as the drum rotates, fluids and small particles pass straight through the slots, whilst the larger solids are carried round on the periphery of the drum to the combs, where they are reduced by successive cutters to particles which can pass through the slots. Comminutors thus provide a single piece of equipment which, in a sewage or similar works, can perform the combined work of a screen, a raking gear, a conveyor and a disintegrator.

The machines are made in a range of standard sizes to deal with flows of from 30,000 to 20,000,000 gallons a day. Normally, the machines, with the exception of the smallest model, are installed in intake sumps with the drums immersed in the fluid. The smallest model has its drum within an open-topped cast iron chamber and has inlet and outlet connections

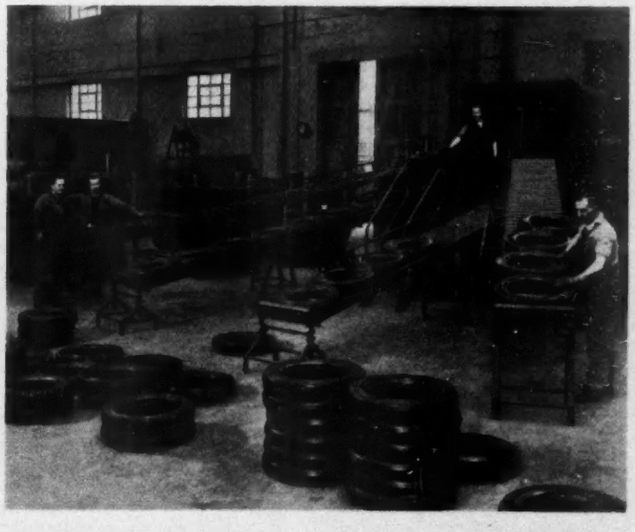


Improved design of small comminutor fitted with automatic lubrication unit

for coupling to a pipeline system carrying the fluid. In the redesigned model the cutting chamber within which the drum rotates is totally enclosed, as shown in the accompanying illustration. With this design the comminutor can be used in locations where the head is sometimes excessive, such as between a storage well and pumps, or where there is an excessive wet weather flow. This small machine is driven by a ¼ h.p. motor through a reduction gearbox which gives a drum speed of 58·5 r.p.m. A further development which is for use on all sizes of these machines is an automatic lubrication unit for the bearings.



Main motor-car stores area at Fort Dunlop works. The special part pallets used are adaptable for the accommodation of all sizes of tyres



Unloading and sorting station of motor-car tyre stores with initial sorting being carried out at the vehicle platform, and final sorting at conveyor unloading point

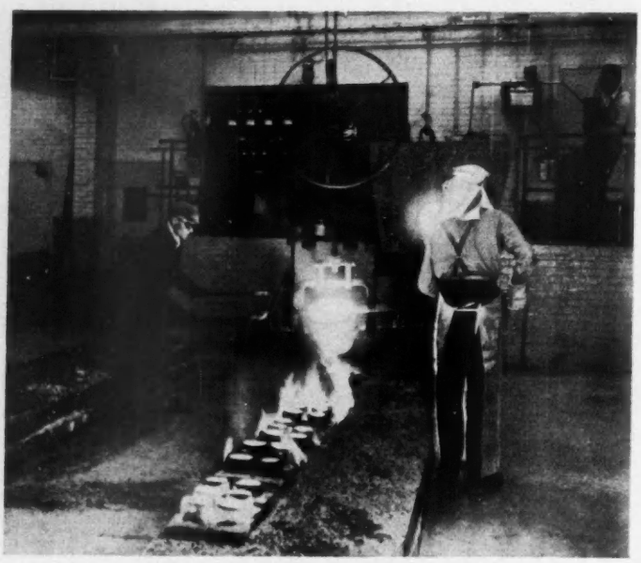
Foundry for Small Precise Steel Castings

A NEW foundry for the production of a wide range of small high-quality precise castings in alloy, manganese and carbon steels has been opened on the Holbrook Industrial Estate, near Sheffield, by Osborn Precision Castings, Ltd., a subsidiary of Samuel Osborn and Co., Ltd. It is capable of producing castings weighing up to 40 lb and is equipped for production by the shell mould, the "Osborn-Shaw" or the "Osborn CO_2 block" processes. At present working a 44-hour week the output totals some 10 tons; facilities are provided however for a rapid extension of the initial production capacity as it is warranted.

The new works is situated at one corner of a 70-acre site which has been acquired to provide for future extensions, and at present it consists of a single storey office block with a separate foundry building at the rear. This foundry building consists of two 200ft long 50ft span bays with a 200ft long 28ft span annexe down one side.

The main foundry floor runs down the centre bay of the building with the annexe on one side and the fettling and finishing bay on the other. The annexe provides accommodation for the ancillary departments of the foundry, and its sections include a sand reclamation plant, pattern stores, pattern and plant maintenance shop, a laboratory and a ladle preparation bay.

The foundry bay is arranged for a straight line production flow. Sand and associated materials are received at one end of the bay and after the necessary processing are distributed to the moulding and core making sections of the shell moulding shop which are set side by side across the bay. The moulds and cores are transferred on racks to the subsequent closing section whence, after assembly, they are moved into a storage area where they are returned for a short time before casting is carried out. This storage area enables complete heats of moulds requiring any one grade of steel to be stored together ready for transfer to the pouring lines.



Electric furnace platform and pouring troughs for shell moulds

Metal is supplied to the pouring lines by one 1 cwt and three 5 cwt capacity high frequency furnaces to which power is supplied by two 200kVA generators. The furnace platform and one end of the shell moulding lines can be seen in the photograph we reproduce. The furnace platform is served by a monorail from an adjoining area used for scrap and metal storing. Extensions of this monorail system are carried over the ladle preparation area at the side of the furnace platform, and out over the mould filling troughs on the shop floor. The monorail hoists handle the shanks and ladles for normal purposes but hand shanks are used when pouring metal into very small casting moulds.

From the pouring troughs the moulds are taken in pairs to a roller conveyor on which they are returned until a release note has been received from the laboratory. The castings thereafter pass in sequence down the fettling bay through a cut-off section, a storage and shotblast area, grinding and trimming sections to the final inspection and despatch departments at the lower end of the bay. A particularly effective dust extraction system, which serves all working stations on the fettling shop benches and all of the machines in it, maintains a high standard of atmospheric cleanliness throughout.

In a foundry of this kind producing both carbon and alloy steel castings the provision of adequate heat treatment facilities is of particular importance, and a furnace section has been installed in one corner of the fettling bay for this purpose. The high temperature hardening furnaces are used for stainless and austenitic manganese steels which require air cooling or water quenching. These furnaces have a temperature range of 650 deg. to 1150 deg. Cent. with atmosphere control and the castings can be drawn out to fall directly into a water quench situated immediately below the doors. A third furnace with a temperature range of 650 deg. to 1000 deg. Cent., can be used for annealing, normalising and oil quenching carbon and low-alloy steels. It can also be used for hardening martensitic stainless steels which require oil or air hardening. The other equipment in this section includes a tempering furnace, a twin-pot salt bath and a degreasing unit.

For the Osborn-Shaw process a bench moulding technique has been adopted and installed in a small separate shop in one part of the foundry. In this practice the mould material consisting of a solution of ethyl silicate and sillimanite in the form of slurry is poured over the pattern enclosed by a wooden surround, and the gelling reaction is so controlled that within a matter of a few seconds slurry is changed to a tough rubbery gel which eventually solidifies. The mould is stripped from the pattern whilst in the rubbery condition, making it possible to use patterns without any draw or taper and in some instances with a slight undercut. Immediately the moulds have been removed from the pattern they are placed on a firing table near to the moulding bench to ensure the rapid removal of the alcohol.

After cooling, the moulds are transferred to a closing station where the top and bottom sections are bound together by a further solution of coarser sillimanite, and again burned off. Before pouring, the moulds are baked in a gas-fired furnace at 1000 deg. Cent. to ensure that the refractory material is properly converted into a mullite. Various refractory mixes are used. In some instances use is made of a fine facing mix of sillimanite with a backing mix of coarse molochite and used refractory. A unit mix of coarse and fine sillimanite or molochite is also used.

One of the advantages of this process is that the refractory is placed over the pattern in the form of a slurry, which ensures that the profile of a pattern is carefully reproduced in the mould, and it thus lends itself to the manufacture of very intricate and complex shapes of varying section thickness. As metal can be poured into hot moulds, it is possible to produce castings of thinner cross-sectional area than by normal techniques. Sections of $\frac{1}{8}$in and $\frac{1}{16}$in are considered a practical proposition. The flexibility of the process makes it of particular value in development and prototype work, and the firm has often produced prototypes from wooden patterns before bulk production of a casting has been introduced in the shell moulding section.

The CO_2 process of moulding is relatively new to this foundry, but it is considered that it will prove a useful adjunct to the shell moulding and "Osborn-Shaw" processes, particularly for the production of carbon steel castings. This technique, in which the mould is produced with a sodium silicate bond hardened by CO_2, has proved a means of raising the standard of steel castings made by conventional methods. The company points out that until recently it has been unable to meet a demand for small steel castings of dimensional tolerances similar to those achieved by the shell mould and Osborn-Shaw processes, but at a price comparable to those possible by normal sand-moulding techniques. In some instances it has been found impossible to cast certain shapes in carbon and low-alloy steels by the shell-mould process, although successful results have been achieved with the Osborn-Shaw process, but at a price which makes the final product uneconomical.

The basic core block technique used in the foundry is called the "CO_2 block" process and it has proved valuable for both jobbing work and on a mechanised basis, using moulding machines with boxes or snap flasks. The use of fine-grade refractory sand gives a very good finish but not of such a high standard as can be achieved by the "Osborn-Shaw" process. A very wide range of alloy steels can be successfully cast into moulds of this type and in certain instances metal is poured into hot moulds. This CO_2 process is now to a large extent replacing the "Osborn-Shaw" process for the development of prototypes, whilst it has also been found that it can be used for making many components which hitherto had to be made by the "Osborn-Shaw" process.

Dense Polythene Tube

THE British Standards Institution is at present considering a specification for dense polythene tube for water services. As the need for a practical guide is deemed by the British Plastics Federation to be urgent, however, that body has issued an advance specification; this will lapse automatically when the British Standard Specification eventually appears. The composition of the material is closely defined, the only additives specified being those approved by the Ministry of Food. Two to three per cent by weight of carbon black is called for, and 0·2 to 0·3 per cent of anti-oxidant, all evenly dispersed. The carbon black must be of channel type, with specific gravity 1·5 to 2·0. When extruded into tube, three samples (each at least 1ft long) must suffer respectively internal hydraulic pressures such that the hoop stresses are 568 lb, 497 lb and 426 lb per square inch, while immersed in water at 80 deg. Cent.; these tests must last 55, 95 and 175 hours respectively, without any sign of failure. Dimensional limits are prescribed in two tables for tubes nominally taking 150 lb and 90 lb per square inch. Nominal bores range from $\frac{1}{2}$in to 2in. Tubes must be marked indelibly in white to show the maker's name, the pressure, and the number of the specification (B.P.F. 42), and this identification must be repeated at intervals of not more than 20ft. Each tube must be tested at room temperature under twice the specified working pressure. The pressure must be established in not less than ten seconds and not more than fifteen seconds, and must be maintained for not less than two minutes without the appearance of leakage or weeping. The ultimate tensile strength of the material must be not less than 2700 lb per square inch, and elongation at fracture must be not less than 300 per cent under a prescribed form of test. It is required that a 6in length of tube shall not change its length by more than 2 per cent after immersion in boiling water for one and a half hours.

A booklet entitled *Specification for Tube for Cold Water Services Made from High Density Polythene*, in which the specification is set out in full, is available for 1s. from the British Plastics Federation, 47–48, Piccadilly, London, W.1.

Industrial and Labour Notes

Coal

For over two years, a committee under the chairmanship of Sir Thomas Robson has been examining the costs of coal distribution. This committee's report was published on Tuesday. The report shows that in the coal distribution trade 135,000 workpeople and 55,000 road vehicles are employed, as well as a number of ships, to supply 660,000 non-domestic consumers and 16,500,000 householders. One of the conclusions of the committee is that charges for wholesale services in coal distribution "are not open to serious criticism." But it is considered that the number of coal depots (5800) does need to be reduced. A smaller number of larger depots, it is suggested, together with mechanical handling, would offer the best prospect of improving distribution efficiency.

One of the committee's recommendations is that, pending the ultimate replacement of the national flat rate profit allowance by a regional allowance, merchants should be allowed an increase of 6d. a ton in areas allowed 50 cwt of house coal a year and 1s. 6d. a ton in other areas. But this recommendation is already out of date, for on Tuesday the Minister of Power announced the end of coal rationing. This will take effect about the middle of July, and, at the same time, price control of house coal, coke and manufactured fuels will end.

Apprentice Awards

Last Saturday, at a ceremony at Rugby, more than 200 engineering apprentices of The English Electric Company, Ltd., received merit awards and indentures from Sir John Woods, a director of the company. On the same occasion the examination results were announced of fifty of the company's engineering students who are taking external degree and certificate courses at the Rugby College of Technology and Arts.

In his annual report, Mr. L. Du Sautoy, chief of personnel and training at the company's Rugby works, announced a new kind of course for craft apprentices. He said that, in an attempt to reduce the wastage rate of craft apprentices who embarked upon City and Guilds courses but never completed them, The English Electric Company, Ltd., had introduced at Rugby a sandwich course made up of three months' full-time study each year at the technical college, instead of the existing system of a day a week throughout the five years' apprenticeship. Mr. Du Sautoy said that the first group of apprentices had now completed their period of study at the Rugby College of Technology; the results, which so far were most encouraging, were being watched with interest by many educational authorities.

Employment and Unemployment

During the month of April, the number of people in civil employment in Great Britain rose by 24,000 to a total of 23,046,000 (15,283,000 men and 7,763,000 women). There was a seasonal increase in the number engaged in agriculture, and there were also increases in the numbers employed in "professional, financial and miscellaneous services" and in the distributive trades. But in the manufacturing industries there was an overall decline, during April, of 11,000 in the number employed.

At the end of April, the manpower strength of the manufacturing industries was 9,203,000, compared with 9,266,000 a year earlier. In the engineering, metal goods and precision instruments group the number of people at work at the end of April was 2,814,000, which was 5000 fewer than a month earlier. There was also a drop of 1000 in the labour force of the vehicle building industry, making the total employed there 1,249,000.

In its report on the matter, the Ministry of Labour says that, in the four weeks ended May 7, the employment exchanges filled 158,000 vacancies. The number of vacancies notified to the exchanges, but still unfilled on May 7, was 208,000, which was 10,000 fewer than at the beginning of April. The Ministry says also that the number of operatives working short time in the manufacturing industries in the week ended April 26 was 165,000, or 46,000 more than a month earlier. About unemployment, the Ministry reports that, on May 12, there were 448,000 people registered as out of work. Of that total, 389,000 were stated to be wholly unemployed and 59,000 were temporarily stopped. Between April 14 and May 12 unemployment in Great Britain increased by 4000, the number of people temporarily stopped increasing by 22,000 and the number of wholly unemployed declining by 18,000. Expressed as a proportion of the estimated number of employees, unemployment in May was 2·1 per cent, compared with 2 per cent in April and 1·5 per cent in May of last year.

Mechanical Stokers in Smoke Control Areas

The Coal Utilisation Council has recently presented a memorandum to Lord Mills, Minister of Power, inviting him to represent to the Minister of Housing and Local Government that it would be desirable for a general exemption to be given, under the appropriate section of the Clean Air Act, 1956, to furnaces fired by mechanical stokers, in smoke control areas established under the Act. This memorandum pointed out that an exemption had already been granted for oil-fired boilers, provided that they were so installed, maintained and operated as to minimise the emission of smoke; it was, therefore, submitted that mechanically-fired boilers using coal should be granted a similar exemption, subject to a similar safeguard. Such an exemption, the Council said, would permit small coal to be burned efficiently, with the same degree of smokelessness as oil, and ensure that maximum use continued to be made of indigenous as opposed to imported fuel. It would also serve to minimise sulphur emission, since in general the sulphur content of industrial coals is less than that of imported fuel oils. Although the Act permits local authorities to grant exemptions, and a number have already done so, a Ministerial exemption, it was urged, would secure uniformity of action over the whole country, and property owners and architects contemplating the use of mechanical stokers would not need to become familiar with different requirements of different authorities.

The Coal Utilisation Council pointed out in the memorandum that if there were no Ministerial exemption and no general exemption in a local authority's smoke control order, mechanically-fired boilers could not be installed unless an amending order was made. Furthermore, uncertainty as to the attitude that local authorities would adopt would discourage prospective users from even considering the installation of mechanical stokers in any area that might become subject to smoke control; this would have a most adverse effect on the development of an important section of solid fuel appliance industry. It would also discourage the promising research work, at present in progress by the British Coal Utilisation Research Association, and elsewhere, on the development of small mechanical stokers, for the smokeless combustion of coal. In the preamble to its memorandum, the Council said that although its task was to promote the efficient domestic use of solid fuel, and the main use of mechanical stokers was in connection with industrial furnaces, the use of these stokers in large houses, blocks of flats, schools and similar domestic and quasi-domestic premises represented an important and efficient use of coal, which might be expected to increase as central heating became more popular.

"Elusive Conceptions of Wages"

The June number of the *District Bank Review* contains a study, by Mr. Theodore Procter, of the difficulties arising from the "vagueness of the current conceptions of wages." The orthodox economist, Mr. Procter remarks, claims that a wage will equal what the industry can afford to pay for a particular class of labour under competitive conditions of production. But organised labour insists that this method of payment tends to depress the wage below a reasonable level. Exactly what a living wage may be, Mr. Procter adds, is a matter of opinion. For some, he suggests, it is the maintenance of the cost-of-living value of a negotiated wage; for others it is such a sum as will guarantee "a given basket of commodities to every household."

Mr. Procter goes on to discuss the conflict between a view of wages that is based on the reward of skill and a view which asserts that the reward of every workman, no matter what his degree of skill, should be large enough to satisfy his needs. If needs are elaborated faster than skill advances, how, Mr. Procter asks, can industry find a workable link between a living wage and the output of the wage-earners? Current events reveal sharply, he says, the contrast between a conception of what a wage ought to be and the rate of pay that an industry can sustain out of its trading revenue. Another problem is posed, of course, by the theoretical contention that in a perfectly competitive market all rewards would tend to be equal. The trade unions, Mr. Procter points out, are not attracted by that argument, except at the datum line. Above the minimum the craftsman is vigorously pursuing the increase of his differential, and he does not accept the idea that a living wage should act as a leveller for all rates of pay. Altruism, based on the need to live, Mr. Procter remarks, and individualism, based on the legitimate reward of skill, contend for priority and frequently get mixed in present debates.

Mr. Procter concludes his study by commenting that adjustments are taking place in wages by the use of comparisons between occupations which are deemed comparable in skill and responsibility. The method, he says, is arbitrary and does not yield any information about the ability of the "comparable" industries to pay the same marginal rates. At best, the determination of a rate of pay or a scale of wages is a very approximate assessment of either skill or need. The urgent problem, Mr. Procter asserts, is to decide which basis shall be recognised as the starting point of the overhaul of industrial wage structures.

West German Brown Coal

No. II—(*Continued from page 868, June 6*)

A substantial proportion of the German Federal Republic's electricity, and large amounts of domestic and industrial fuel, are derived from lignites, the largest deposits of which are found in the Rhineland west of Cologne. The present article reviews the development of this coalfield which, since the war, has undergone an unprecedented expansion. Since we published our article on this subject ten years ago, deep opencast mining, the feasibility of which was then still under debate, has made rapid strides through the introduction of extra-heavy machinery.*

The "Fortuna" Power Stations

THE three "Fortuna" power stations belong to Rheinische Aktiengesellschaft für Braunkohlenbergbau und Brikettfabrikation" (R.A.G.), of Cologne. The earliest dates back to 1914, but of the oldest installation only three 80-atmosphere boilers remain. These part-supply the machines of No. I station, the rest of the steam requirements being derived from "Fortuna II." A back-pressure turbine supplies the neighbouring briquette factory "Fortuna." No. II station consists of a modern high-pressure installation comprising 10 h.p. boilers and 5 h.p. turbines, together with low-pressure turbo-sets, which previously belonged to an intermediate-pressure installation. "Fortuna III" is laid out in pure block arrangement, and its most recent sets, Nos. 1 and 2 are of 150MW each: these have the lowest specific consumption amounting to 2600kcals per kilowatt-hour. On page 907 we show sectional elevations of this station and a turbine set.

In all stations the cooling water is recirculated, make-up being supplied from a 3km-distant waterworks. Most of the generated power is supplied into the grid of Rheinisch-Westfälisches Elektrizitätswerk A.G. (RWE). In addition, eight 25kV cables directly supply the city of Cologne. For the R.A.G. mines and the mine pumping stations in the Erft basin, overhead lines of 15kV, 25kV and 110kV are installed.

The photograph opposite shows "Fortuna II" and "Fortuna III" stations. Coal supplies arrive by two conveyor belts from two low-level bunkers, which receive coal from the mine in 100 cubic metres capacity mine cars. One bunker is a 12,000-ton pit bunker, the other a 14,500-ton bunker with longitudinal discharge slot. Together they suffice for eight to ten hours' full-load operation. Station I obtains its coal from the briquette factory.

Ash from the flue gas separator is pneumatically conveyed to a central 3500 cubic metres bunker. Scroll conveyors deliver it to railcars, at the same time the material is damped. Some of it is manufactured into cement. Ash from the combustion chambers and heating surfaces of the boilers is deposited in water troughs fitted with chain conveyors, and discharged into cars over belt conveyors.

Water treatment is carried out centrally. Cooling water is presoftened by the addition of hydrate of lime, and then completely softened in a regenerative ion exchanger. Make-up boiler feed is obtained from evaporator plant in Nos. II and III stations, which are fed with water prepared in a hydrogen exchange plant which can be regenerated by means of sulphuric acid and sodium chloride. The process eliminates in one stage all carbonic acid and achieves complete softening. After driving off all free carbon dioxide by spraying, trisodium phosphate is added before the water is pumped into the evaporators. A slight degree of alkalinity is always maintained in the boilers by adding the required small amounts of "Diamonphosphat." In the Benson boilers, hydrazin is added.

The principal technical data are listed in tables on this and page 908. Because an increase in ash content was expected over the years, the boilers were laid out with this fact borne in mind. Capacities refer to a calorific value of the raw brown coal of 2000kcal per kilogramme in No. I station, 1800kcal per kilogramme in No. II, 1650kcal per kilogramme in blocks 3 and 4 of No. III, and 1450kcal per kilogramme in blocks 1 and 2 of No. III station.

In "Fortuna II," nine natural convection cooling towers cool 58,000 cubic metres per hour from 37 deg. to 27 deg. Cent, and three forced convection towers cool 21,750 cubic metres per hour from 37 deg. to 20·5 deg. Cent. In the latest station, "Fortuna III," six forced convection cooling towers have been installed, capable of cooling 62,400 cubic metres per hour of water from 31·5 deg. to 21 deg. Cent.

Control of the boilers is centralised. In the "Fortuna II" control room, one desk is provided for each two boilers, which are operated fully

* "Opencast Mining in the Rhine Brown Coalfield," by W. L. G. Muir, THE ENGINEER, April 9, 1948, page 344; April 16, page 368, and April 23, page 392.

TABLE IV—"*Fortuna I*" *Power Station*—Three pulverised-fuel, high-pressure boilers

Boiler No.	1	2	3
Maker	Dürr	Steinmüller	Steinmüller
Year	1937	1937	1943–46
System	Natural circulation	La-Mont	La-Mont
Capacity, tons per hour	90	90	125
Equivalent standard evaporation, tons per hour*	87·5	87·5	125
Pressure, atmospheres gauge	71	71	71
Temperature, deg. Cent.	510	510	510
Feed temperature, deg. Cent.	195	195	180
Hot air temperature, deg. Cent.	370 (60 per cent) 210 (20 per cent)	400 (65 per cent) 240 (27 per cent)	310 (75 per cent) —
Flue gas temperature (normal load), deg. Cent	200	200	200
Boiler efficiency, per cent	82	82	82
Firing	Front	Front	Counter
Coal mills:			
Number	3	3	4
Maker	Fränkel and Viebahn	Steinmüller	Steinmüller
Design	Impact	Impact	Impact
Capacity, tons per hour	12·2	8–11	12·8
Flues gas cleaning	← Electrostatic →		
Percentage at normal load	85	85	90

Turbo-generators

Sets No.	1	2	3	4	5	6
Maker of turbine	AEG	SSW	AEG	AEG	AEG	MAN
Year	1929	1929	1936	1938	1953	1951
Design	← Single-cylinder axial →					Ljungström
Nominal capacity, megawatts	15·7	16·1	8·0	8·0	10·5	25·0
Steam:						
Pressure (atmospheres gauge)	14	14	65	65	14·5	64
Temperature (deg. Cent.)	350	350	500	500	360	500
Back pressure (atmospheres gauge)	0·07	0·07	15	15	5·5	0·07
Feed inlet temperature, deg. Cent.	← 27 →					
Maker of generator	AEG	SSW	AEG	AEG	AEG	SSW
Capacity, mega-volt-amperes	22·4	23·0	11·4	11·4	15·4	32·0
Voltage, kilovolts	6·3	6·3	6·3	3·3/6·3	6·3	12·5

* Equivalent saturated steam at 1 atmosphere from feed water at 0 deg. Cent. (640 kcal per kilogramme).

TABLE V—"*Fortuna II*" *Power Station*—Ten pulverised-fuel boilers with reheat

Numbers	1 and 2	3 and 4	5 to 8	9 and 10
Maker	MAN	Walther	Babcock Dürr Steinmüller VKW	Walther MAN
Year	1950	1950	1950	1953
System	← Natural circulation →			
Continuous steam capacity, tons per hour	175	175	175	250
Equivalent standard evporation, tons per hour	196	196	196	298
Steam:				
Pressure (atmospheres gauge)	← 117 →			
Temperature, deg. Cent.	510	510	510	530
Feed inlet, deg. Cent.	150	150	150	180
Reheat:				
Superheater, atmospheres gauge	← 17–16 →			
Temperature, deg. Cent.	278/410	278/410	278/410	290/480
Tons per hour	160	160	160	237·5
Hot air temperature, deg. Cent.	30–268 (75 per cent)	30–268 (75 per cent)	30–268 (75 per cent)	30–275 (86 per cent)
Flue gas temperature, deg. Cent.	180 (13 per cent CO_2)	180 (13 per cent CO_2)	180 (13 per cent CO_2)	160 (14 per cent CO_2)
Boiler efficiency, per cent	82	82	82	84·5
Firing	← From corners →			
Mills per boiler	← Four →			
Maker	KSG	KSG	Babcock	Babcock
Capacity, tons per hour	27	27	27	35
Air preheater	← Ljungström →			
Fly ash separation, per cent	85	90	85	92

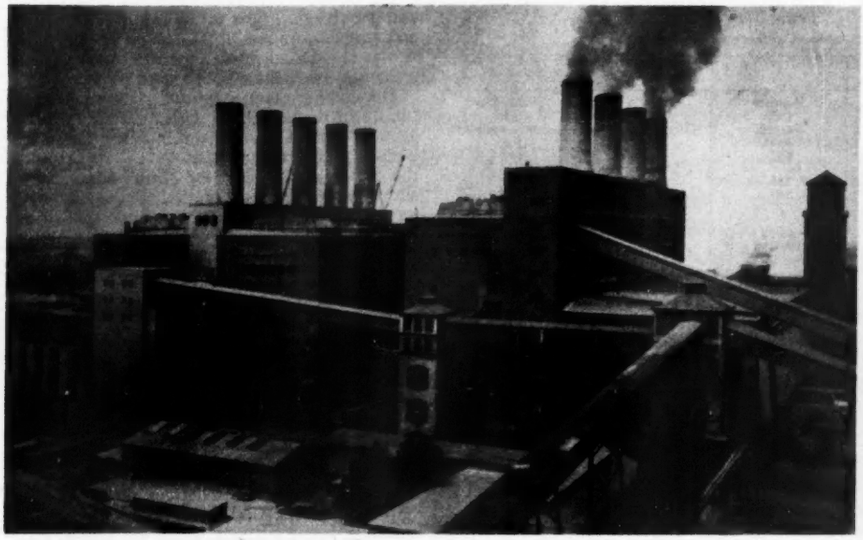
Turbo-generators—(i) High-pressure installation

Numbers	V1 to V4	V5	Vorw. Turb.
Maker	MAN	MAN	SSW
Year	1951	1954	1951
Design	Ljungström	Ljungström	Axial
Capacity, megawatts	35	52	6
Steam at inlet:			
Atmospheres	114	115	15
Deg. Cent.	500	520	400
Back pressure (atmospheres)	19	19	5
Generator	SSW	SSW	SSW
Mega-volt-amperes	43	64	8
Voltage, kilovolts	10·5	10·5	6·3

(ii) Low-pressure installation

Number	N2	N3	N4 and N7	N5	N6	N8
Maker	MAN	AEG	MAN	MAN	SSW	SSW
Year	1922	1951	1939	1951	1928	1954
Design	Axial	Axial	Ljungström	Ljungström	Thyssen-Röder (2 cylinders)	Axial (2 cylinders)
Capacity, megawatts	16	31	35	35	25	90
Steam:						
Atmospheres	14	14·5	14	14·5	14	15·5
Deg. Cent.	350	400	350	400	350	470
Cooling water at inlet, deg. Cent.	27	27	27	27	27	20
Generator:						
Maker	SSW	AEG	SSW	SSW	SSW	SSW
Mega-volt-amperes	23	44·3	43	43	42·8	129*
Kilovolts	6·3	10·5	11·7	10·5	6·3	10·5

* Hydrogen cooled.



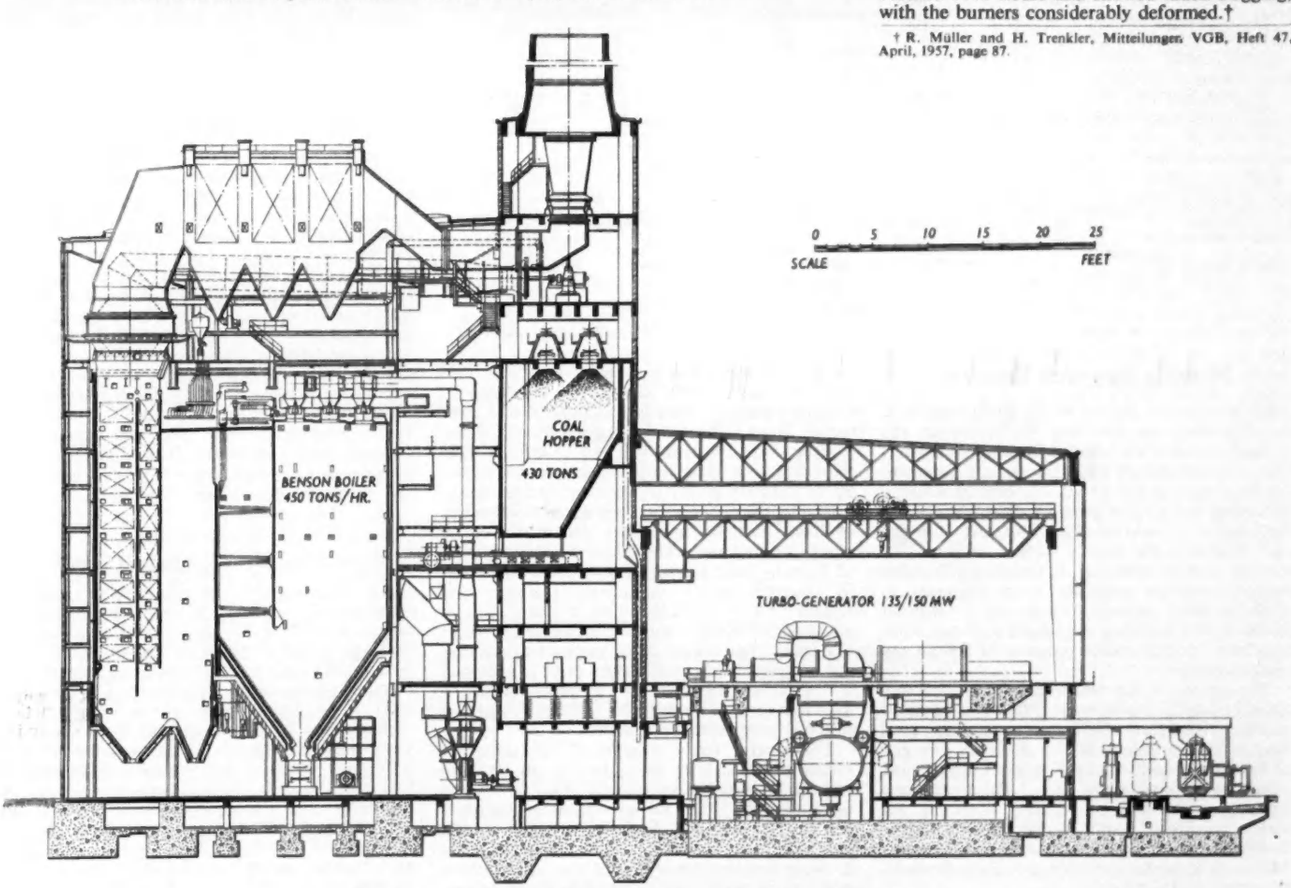
View from south of power stations "Fortuna II" (left) and "Fortuna III"

automatically with equipment supplied by Siemens and Halske. The electrical output and station demand are also indicated and recorded. "Fortuna III" has one control room for each two blocks, the boilers are fully automatic with inductive control (Nos. 1 and 2, Siemens and Halske; Nos. 3 and 4, Schoppe and Faeser).

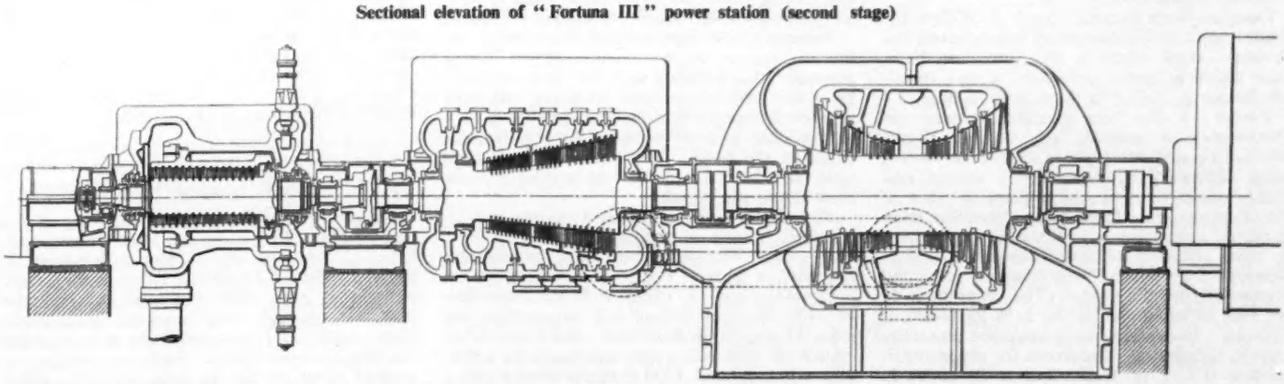
For "Fortuna II," which has an enclosed volume of 495,000 cubic metres, 51,000 cubic metres reinforced concrete with 5150 tons reinforcements, and 6500 tons of structural steelwork were required. In the case of "Fortuna III," the enclosed volume is 450,000 cubic metres, the amount of reinforced concrete was 52,000 cubic metres with 4500 tons of reinforcements, and 5800 tons of steel structures were required. If one considers that the two stations have capacities of 355MW and 500MW, respectively, the saving on the size of the building per megawatt installed is very striking for the larger sets.

With regard to the various burner arrangements used in "Fortuna III," it is stated that the front-fired No. 4 boiler reached an operating time before the first overhaul of 8000 hours, when it was found that hardly any deposits had been formed, and that the state of the burners was practically as new. On the other hand, the corner-fired No. 3 boiler of the same capacity reached 5700 hours and showed much slagging, with the burners considerably deformed.†

† R. Müller and H. Trenkler, Mitteilungen VGB, Heft 47, April, 1957, page 87.



Sectional elevation of "Fortuna III" power station (second stage)



150MW condensing turbine at the "Fortuna" power station of R.A.G. Steam conditions at the turbine intake are 180 to 200 atmospheres; 525 deg. to 530 deg. Cent. reheat is used

TABLE VI—"*Fortuna III*" *Power Station*

Four pulverised-fuel boilers in block arrangement with one turbo-set each

Boiler No.	1	2	3	4
Maker	Steinmüller	Walther	VKW	Steinmüller
Year	1955	1955	1954	1954
Design	Benson	Benson	Natural circulation	Natural circulation
Steam, tons per hour	450	450	360	360
Equivalent standard evaporation, tons per hour	482	482	347	347
Steam :				
Atmospheres gauge	185	185	115	115
Deg. Cent.	530	530	530	530
Feed, deg. Cent.	230	230	200	200
Intermediate superheater :				
Atmospheres gauge	33/32	33/32	None	None
Deg. Cent.	300/350	300/350	None	None
Tons per hour	415	415	None	None
Hot air temperature, deg. Cent.	30–280 (85 per cent)			
Flue gas temperature, deg. Cent.	160			
Boiler efficiency, per cent	85 (13·8 per cent CO_2) (1450 kcal/kg.)	85 (13·8 per cent CO_2) (1450 kcal/kg.)	84·5 (13·5 per cent CO_2) (1650 kcal/kg.)	84·5 (13·5 per cent CO_2) (1650 kcal/kg.)
Firing	Roof	Roof	Corners	Front
Fuel mills	6	6	4	4
Maker	KSG			
Capacity, tons per hour	45			
Flue gas filter	Electrostatic			
Efficiency, per cent	95	95	92	92
Feed pumps	3	3	—	—
Maker	Halberg			
Capacity (each pump), tons per hour	225			
Delivery (atmospheres gauge)	260	260	152	152
Drive motors, kilowatts per pump	2650	2650	1550	1550

Turbo-generators

Turbine, maker	SSW	AEG	MAN	AEG
Year	1955	1955	1954	1954
Design	3-cylinder axial with reheat		3-cylinder axial	
Capacity, megawatts	150	150	100	100
Steam :				
Atmospheres gauge	180		109	
Deg. Cent.	525			
Bleed-off points	7	7	5	5
Cooling water inlet, deg. Cent.	21			
Generator, maker	SSW	AEG	SSW	AEG
Capacity, mega-volt-amperes (hydrogen cooled)	187·5	189·5	143	143
Voltage, kilovolts	10·5			
Cos φ	0·8		0·7	
Generator transformers :				
Maker	SSW			
Mega-volt-amperes	200	200	150	150
Ratio, kilovolts/kilovolts	245/10·5 ± 11 per cent		245/10·5	
Regulation transformer, mega-volt-amperes	None	None	150	150
Range, kilovolts	None	None	10·5 ± 11 per cent	10·5 ± 11 per cent
Station supply winding	None	None	10·5/6·3kV, 12·5MVA	10·5/6·3kV, 12·5MVA
Station transformer	16MVA, 10·5/6kV	16MVA, 10·5/6kV	None	None

(*To be continued*)

Munich Research Reactor

In our issue of December 20, 1957, page 915, we described the building which houses the research reactor of Munich Technical University. An egg-shaped structure of shell concrete, the building is of great civil engineering interest, in having a shell thickness of only 10cm for a diameter at ground level of 30m and a height also of 30m. The shell's surface area is 2700 square metres (volume of concrete 270 cubic metres) and the enclosed space amounts to 15,000 cubic metres. Constructed without windows, the building is gastight and can withstand an internal excess pressure of 500 kg per square metre.

The reactor, which was officially inaugurated on February 3, is designated FRM (Forschungsreaktor München). It is a swimming pool reactor to the design of the Atomics Division of American Machine and Foundry Corporation, which also supplied the core. The mechanical equipment was built by M.A.N., Augsburg, the water treatment plant is by Pintsch-Bamag, Butzbach/Hesse, instrumentation by Honeywell, Minneapolis, and electrical equipment by Siemens-Schuckertwerke, Munich.

Designed for a thermal output of 1000kW the reactor has a core consisting of twenty-seven fuel elements which stand in an aluminium baseplate which in turn is suspended from a travelling bridge at the top of the swimming pool.

Twelve of the fuel elements consist of aluminium-clad uranium slabs set in a frame without top or bottom plates so that the cooling water obtains free access. In a second and similar assembly of uranium elements some of the uranium can be replaced by aluminium so as to permit a smoother adjustment of the output. A third assembly of fuel elements comprises channels for stainless steel control rods and boron carbide safety rods. The uranium is 20 per cent enriched, containing 3·58 kg U-235 at the start. In order to compensate for poisoning and the withdrawal of neutrons for experiments, another 0·7 kg of U-235 has to be added in the course of operation.

The total mean flux is stated to be $6 \cdot 6 \times 10^{12}$ neutrons per square centimetre per second. Ordinary water is used as moderator, and protection from radiation is afforded by the water together with the tank walls which consist near the bottom of heavy barytes concrete and higher up of ordinary concrete. For conducting radiation into the laboratories, eight radiation tubes of 15cm diameter have been provided, two of which are inclined. There is one radiation tube of 30cm by 30cm square section, and a tube 10cm in diameter which completely traverses the reactor. Very short irradiation times can be achieved by quickly passing an object through this tube. For reducing the speed of the emerging neutrons to thermal values there is provided a "thermal column" of graphite elements. This measures 1·2m by 1·2m and can be inserted into one of the neutron channels.

The reactor basin consists of two compartments which can be separated by an 8m-high watertight door. One basin is used in normal operation, the other for cooling down purposes and for storing used fuel elements. It is also used for storing the core while the main basin is being emptied for overhaul and adjustments, and can be employed as an underwater laboratory for work with high-strength gamma sources.

Because of the high ground water level, the reactor had to be constructed largely above ground. This, together with the need to handle by crane long components including the tank separating door, made it necessary to have a tall building, and accounts for the peculiar egg-shape of the dome. The overhead crane crab runs on a bridge supported on a circular track fixed inside the cupola.

The reactor is designed for a maximum temperature, in case of accidental overload, of 77 deg. Cent. Normally the water temperature amounts to 30 deg. Cent. The cooling system comprises a primary circuit with maximum flow of 3400 litres per minute and temperature rise from 32 deg. to 36 deg. Cent., and a secondary system fed with well water, and operating normally with a flow of 1200 litres per minute and a temperature rise from 12 deg. to 24 deg. Cent., and a maximum flow of 2600 litres per minute and temperature rise of 24 deg. to 30 deg. Cent. A water softening plant is shunt-connected and has a flow of 76 litres per minute.

The cooling plant is housed in the reactor hall itself and in the cellar. Other installations are grouped round the reactor building in a ring. These comprise lecture halls and changing rooms, the laboratory, workshop and library, two 40 cubic metre waste tanks, a 5 cubic metre mixing tank, two 20 cubic metre tanks, one 146 cubic metre storage tank, and the space heating and fresh water plant. Separate buildings house the administration, the caretaker's flat and garages, and the electric substation. Towards the river Isar lies a large open-air cooling basin. A second large building for laboratories is under construction.

Travelling Crab for Overhead Travelling Crane

We have received details of a travelling crab constructed by Schiess-Defries Hebezeug-und Kranbau G.m.b.H., Düsseldorf-Oberkassel, for handling heavy castings which are subsequently broken up by dropping on them a steel ball carried by a load magnet. The steel ball, which weighs 10 tons, is raised by the load magnet and dropped above the machine part by switching off the magnet current. The crane is controlled from a driver's cage running on top of one of the bridge girders. The main hoist has a speed of 12·5m per minute, and the magnet hoist a speed of 32m per minute, while the traversing speed of the crab is 60m per minute. Each of the lifting motors has a capacity of 64kW and the crab traversing motor has 16kW. The gear wheels of the crab run in split spur-gear-oil boxes which ensure a smooth running of gears, thorough lubrication of gear wheels and bearings and eliminate wear and tear of all moving parts. The bearings of the gear boxes are furnished with anti-friction bearings whereby the efficiency of the gears is increased. Connection of the drums to the drive gears is by means of self-aligning bearings in order to avoid additional stresses on the drum shafts caused by deflection of the crab frame. Electric block brakes are used as braking devices ; these are operated by Siemens brake releasers. The structural steel crab frame is welded, and its weight, including that of the motors, is about 16 tons.

Industrial Management Congress

It is announced that an industrial management congress will be held in Brussels during the period June 25 to 28. It is being organised by the Commission Générale d'Organisation Scientifique (C.E.G.O.S.), with the assistance of the Belgian government department for productivity. The general theme is to be "The Practice of Industrial Management and the Economic, Technical and Social Development in the Modern Industrial Age." The Congress will be held in four sections, viz., factory management and the means for its assistance—economic and technical planning ; development of enterprises and the influence of labour problems ; the enterprise as a human society ; and present development of methods of work and their effects upon the worker. It is the purpose of the meeting to allow an exchange of views between managers and outside experts. Information may be obtained from the Secretary, Mademoiselle Clariond, C.E.G.O.S., 33, rue Jean-Goujon, Paris (8e) (telephone, BAL. 27–30).

French Glider Record

A new absolute altitude record was set up on February 24 by Monsieur Michel Marchand, flying a "Breguet 901" glider with which he reached 10,100m (33,128ft). This performance is remarkable both from the technical and the human standpoints. Marchand and several other pilots, including Jules Landi, who at present are carrying out experimental flights, are exposed to cockpit temperatures at these altitudes which are as low as −30 deg. and even −50 deg. Cent.

Linden Steam Power Station

No. 1

BY OUR AMERICAN EDITOR

The Linden steam power station of the Public Service Electric and Gas Company in New Jersey is one of the most interesting generating schemes to go into operation in the United States recently. The station has been built next to the Bayway refinery of the Esso Standard Oil Company to obtain a mutually advantageous combination of two industrial processes: the processing of crude oil to refined petroleum products and the conversion of refinery residuals to electric energy. The refinery can effectively use the low-level heat energy of the power station, and the power station can make good use of the residuals of the refining processes. The Linden generating station comprises two 225MW turbo-generators having respective throttle pressures of 2000 lb and 2350 lb per square inch gauge and respective superheat conditions of 1050 deg. and 1100 deg. Fah.

THE design of the Linden steam power station of the Public Service Electric and Gas Company in New Jersey constitutes an interesting change of approach to the problem of lowering the operating costs of steam power plants because it is expected to achieve a substantial improvement in economy without an increase in steam conditions. None of the principles applied in this plant is new. However, the size of the equipment, the magnitude of the throttle and process flows, and the high operating economy constitute a significant forward step in steam power engineering. In the electric system of the Public Service Electric and Gas Company, the steam conditions at Linden are about the same as those of other recently installed units, but the economy of operation is substantially better, because the plant has two unusual uses for low-level heat energy that is normally rejected to condenser cooling water: (*a*) the heat required for oil refining processes, and (*b*) the heat required to raise the temperature of that part of the unusually large feed water flow which is the make-up due to the delivery of extraction steam for refining processes.

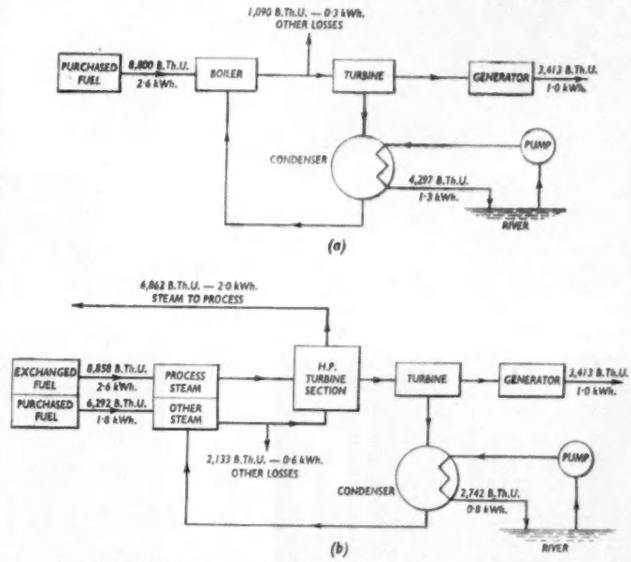
In the past, the price of higher economy has been higher steam conditions and the added complications of such aspects as reheat, pressurised furnaces and gas recirculation. At Linden, the price of the high economy lies in the additional complications of (*a*) automatic steam extraction from the turbines, (*b*) a water treating plant for high make-up, (*c*) the special features for handling and burning high viscosity fuel, and (*d*) the provisions to ensure reliability of steam supply. In the usual application of an extraction steam turbo-generator, the entire output of steam and electric energy goes to the same user, and the necessity of maintaining a balance between the two sometimes results in undesirable limitations in operation. At Linden, however, the steam goes to an oil refinery while the electric output goes to both the refinery and the Public Service grid system. This arrangement makes it possible to build a plant capable of generating highly economical non-condensing power in quantities much greater than the electric requirements of the refinery, which, in this case, buys its electric service from the power company in the same manner as other large customers.

Design Concepts

The construction of the Linden generating station adjacent to the Bayway refinery of the Esso Standard Oil Company is a mutually advantageous combination of two industrial processes: the processing of crude oil to refined petroleum products and the conversion of refinery residuals to electric energy. The contractual arrangement provides that Public Service will deliver to Esso the entire steam requirement of the Bayway refinery in exchange for fuel and raw water. The additional fuel required to operate the units at full electric output is to be delivered by the refinery at commercial rates. The basic fuel for both commitments will be high viscosity residual fuel. When there is not enough, the deficiency will be made up by "Bunker C" fuel oil. Raw water delivered by the refinery in exchange for steam will be purified, filtered and demineralised at the generating station. Electric energy will be delivered to the refinery at regular wholesale rates. The contract runs for twenty years with provision for extension. When steam deliveries are substantial, the service charges for steam are small because of the value of fuel received in exchange. When the steam takings are low, the charges are higher in proportion to the lower operating economy of the plant.

The initial concept was a plant consisting of only one automatic double-extraction turbo-generator of 225MW gross electrical capability supplied by three boilers on a header serving both the turbine and the pressure-reducing and desuperheating units, which by-pass the turbine for delivery of steam from the boilers directly to the refinery. In the earliest studies, turbo-generator sizes of 50MW and 100MW were rejected as considerably less economical than the larger unit. The arrangement of three boilers supplying one turbine, which is unusual to-day, was chosen with reliability of steam supply in mind. Two boilers are sufficient to operate the unit with full extraction flow from the turbine. Throttle steam conditions of 2000 lb per square inch gauge and 1050 deg. Fah. were chosen for the first unit as a design compromise between reliability, cost, efficiency and optimum turbine design for the extraction of process steam. With three boilers, a steam turbine, and two turbine by-passes connected to a double steam header, it was desirable to avoid the complications of reheating and the higher cost of a steam piping system with austenitic steel valves. Therefore, the upper limit for the steam temperature was set to allow the use of ferritic steels. The throttle steam pressure was determined from the exhaust conditions necessary to satisfy the requirements of the refinery. The nominal steam flows in round figures are 2,800,000 lb per hour to the turbine, 400,000 lb per hour of process steam extracted at 750 lb per square inch gauge and 750,000 lb per hour of process steam extracted at 150 lb per square inch gauge. Reducing stations provide for the by-passing of the turbine. The feed-water make-up is about 40 per cent for these flows.

Before final agreement was reached for a



(*a*) 8800 B.Th.U. of purchased fuel produces 1kWh electric energy: Fuel economy is $\frac{3413}{8800} \times 100 = 39$ per cent.

(*b*) 6292 B.Th.U. of purchased fuel produces 1kWh of electric energy: Fuel economy is $\frac{3413}{6292} \times 100 = 54$ per cent.

Fig. 1—Comparison of conventional power station (a), with power station using process steam extraction (b)

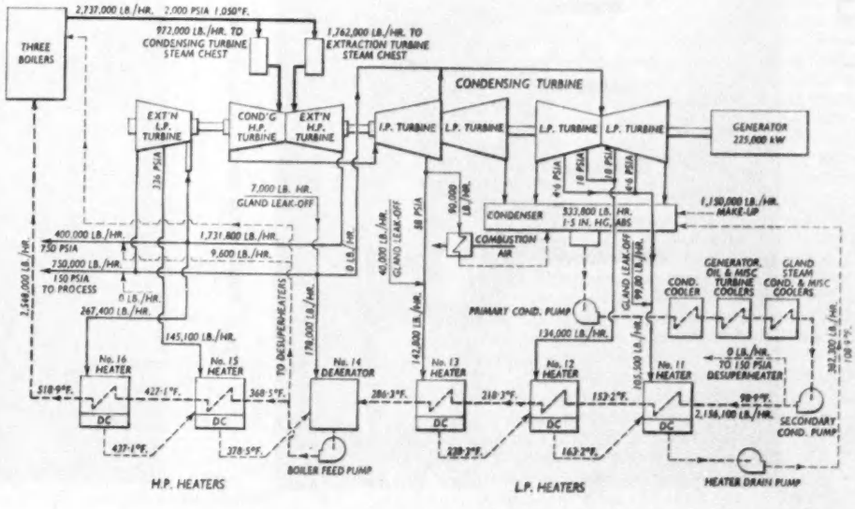


Fig. 2—Heat balance and flow diagram of No. 1 unit

LINDEN STEAM POWER STATION IN NEW JERSEY

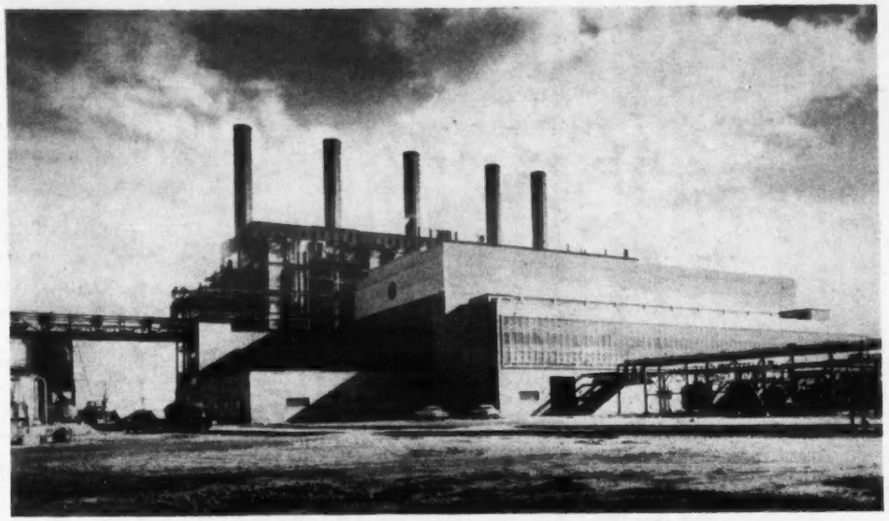


Fig. 3—Linden steam power station, with turbo-generator building in foreground

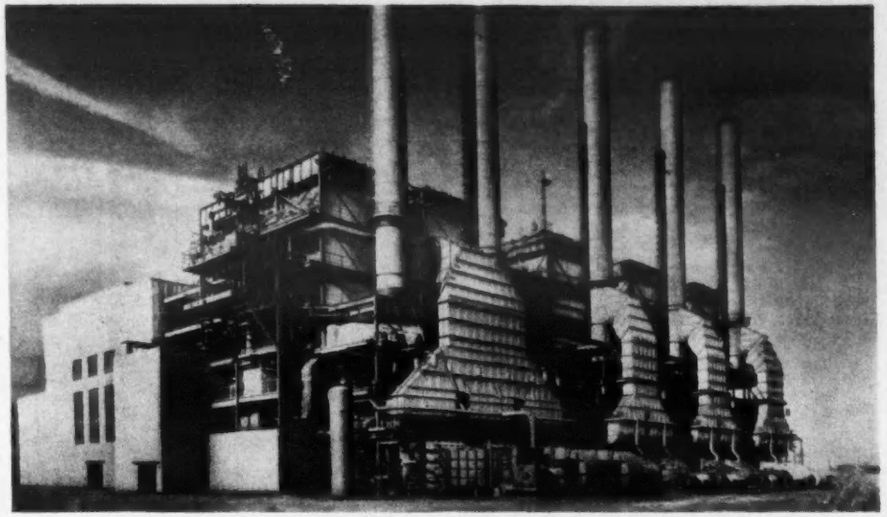


Fig. 4—Boiler section of Linden steam power station, with three units at right supplying one, and one unit at left supplying the other turbo-generator

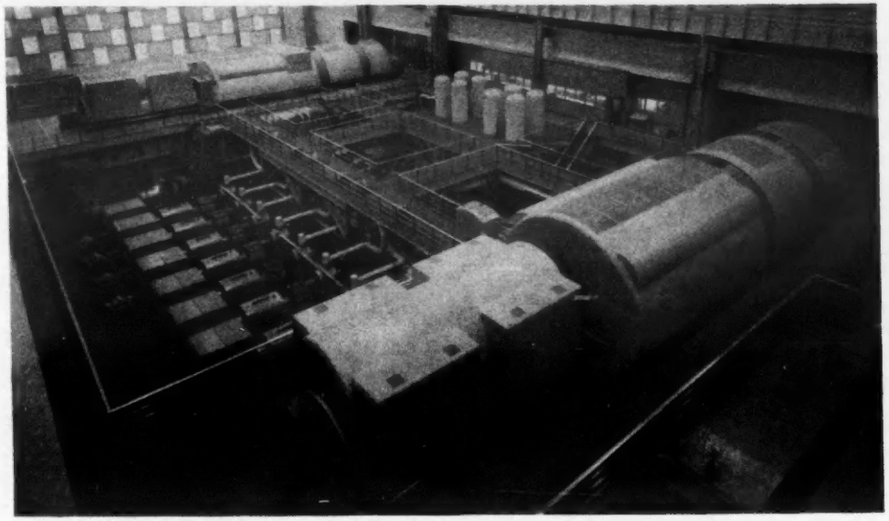


Fig. 5—Turbine room with both 225MW turbo-generators and auxiliary equipment

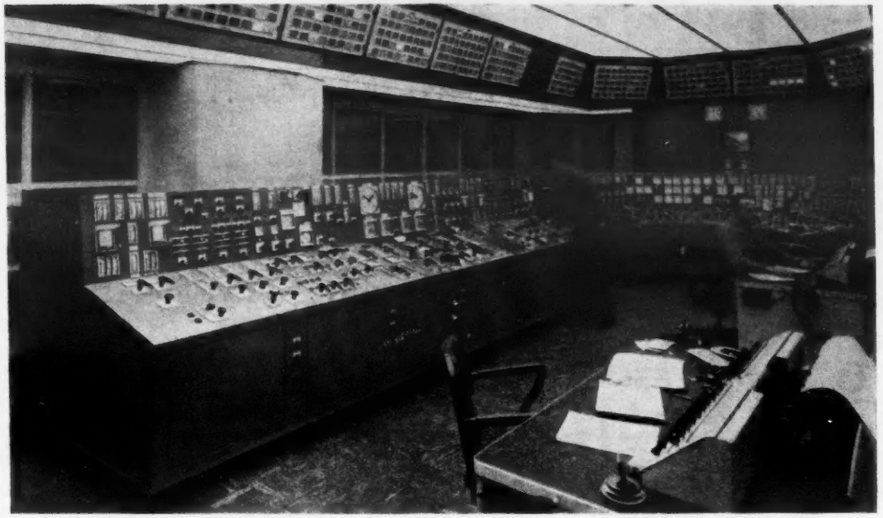


Fig. 6—Control room with turbo-generator and boiler controls and controls for the extraction steam supply

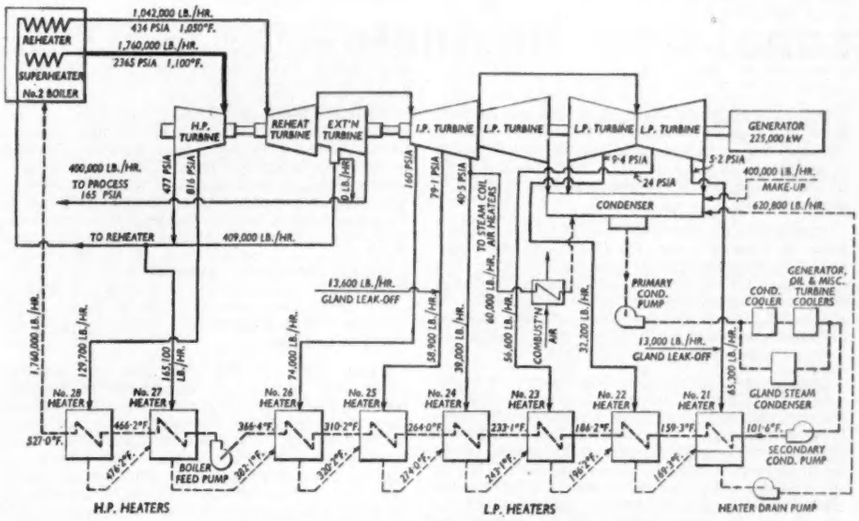


Fig. 7—Heat balance and flow diagram of No. 2 unit

contract covering the operating arrangement for the first unit, it became apparent that another unit would be required soon after the installation of the first unit, to meet the increasing demands of the Public Service electric system. Since the dependability of process steam supply had been designed into the first unit, the approach to the design of the second unit was more in the direction of the concepts used in other recent installations, i.e. high steam temperature, steam reheating and a single boiler for the turbo-generator. However, it was felt that this 225MW unit should also be designed to furnish extraction steam to the refinery at the lower of the two pressures. Thus, there is capacity in the second unit to meet the increasing steam demands of the refinery as it grows. The No. 2 unit involves a throttle flow of 1,820,000 lb per hour and the extraction of 400,000 lb per hour of 150 lb per square inch gauge process steam for the refinery. The throttle steam conditions are 2350 lb per square inch gauge and 1100 deg. Fah., with reheating to 1050 deg. Fah.

The cost of operating the first unit will be relatively insensitive to fluctuations of fuel prices because the amount of exchanged fuel burned is large in respect to the total fuel required, and this makes it unlikely that solid fuel will be burned in the boilers of this unit. However, the plant is laid out with space for the future installation of pulverised fuel equipment. In the case of the second unit, the proportion of exchanged fuel is smaller, and since the period of an assured supply of purchased fuel is shorter, it was decided to construct the boiler of the second unit in such a manner that a minimum outage would be involved in its conversion to pulverised fuel burning.

The economy of operating an extraction steam turbine plant is illustrated in Fig. 1, which shows, in simplified form, the flows of energy in a modern, conventional station compared with a unit similar to the Linden scheme. In both diagrams the electrical product is 1kWh. In terms of purchased fuel, the economy of the extraction cycle is 54 per cent, compared with 39 per cent in a modern condensing station. Of course, there are other differences in operating costs which must be taken into account in an evaluation of the advantages of such plants. Heat balance and flow diagrams of the steam and feed-water systems of the two Linden units are shown in Figs. 2 and 7.

General Arrangement

The Linden generating station is adjacent to the Bayway refinery of the Esso Standard Oil Company at Linden, New Jersey. The property extends about one-quarter of a mile along the west bank of Arthur Kill. It is situated about 7 miles south of the centre of the city of Newark, and about 6 miles north of the Sewaren generating station of Public Service. The placing of the station on the 116-acre site allows room for four more large units in a future extension to the south along the shore of the Kill. The principal areas of the station are : (1) the future pulverised fuel preparation plant ; (2) the semi-outdoor boilers ; (3) the turbine room ; (4) the auxiliary power substation ; (5) the 138kV switchyard ; (6) the 26kV switchyard, and (7) the oil storage and the future coal storage. There is a 6300ft run of pipe from the boilers of the generating station to the existing Esso boiler house, from which steam is distributed to the refinery. There are two 30in lines for low-pressure steam, two 16in lines for high-pressure steam, one 8in line for high viscosity fuel, one 10in line for " Bunker C " fuel, and one 16in line for raw water, with a 16in connection to the Elizabethtown Water Company. The general arrangement plan of the station is shown in Fig. 8. In spite of the fact that the Linden station has a boiler capacity equivalent to a 700MW station and an unusually large water treatment plant, the enclosed volume of the building is about the same as that of the 455MW Sewaren station, which has four conventional units. The control room contains all the usual central controls for the two turbo-generators and the four boilers and, in addition, all the controls for the extraction steam and pressure reducing stations. The complete station operation is handled from this point, excepting the water treatment equipment for which there is a separate control system.

(To be continued)

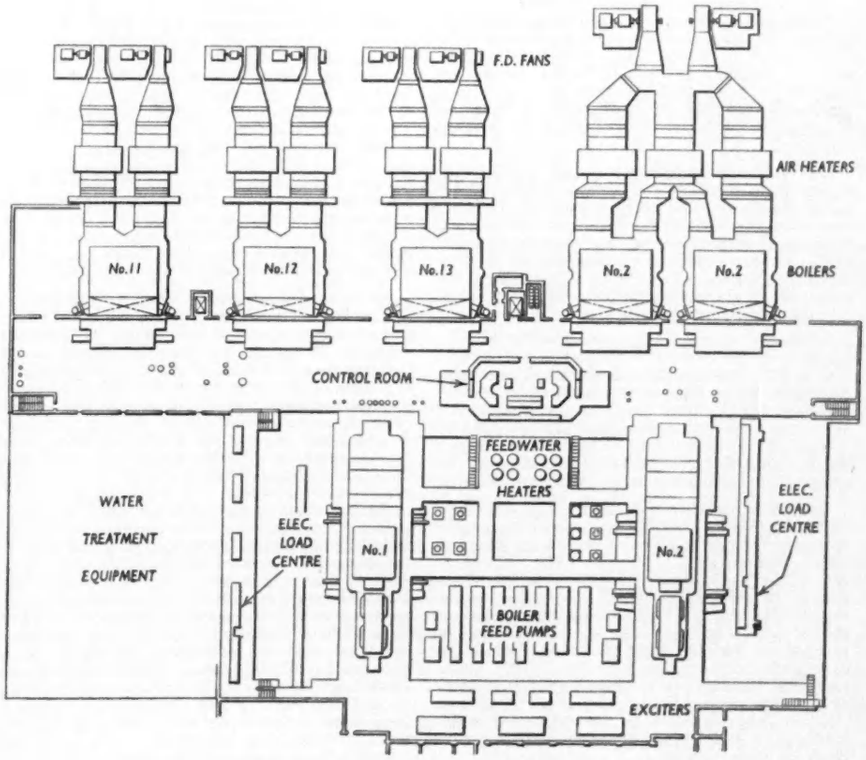


Fig. 8—General arrangement plan of the Linden station

Atomic Power Station at Piqua

The U.S. Atomic Energy Commission has reached agreement with the Atomics International Division of North American Aviation, Incorporated, and the City of Piqua, Ohio, on the basis for contractual arrangements for a demonstration nuclear power plant at Piqua. The basis has been filed with the Joint Committee on Atomic Energy of the Congress in accordance with the requirements of the 1958 authorisation act. The agreement with Atomics International would cover research, development, fabrication and construction of a 12·5MW (electrical) nuelear reactor, moderated and cooled by a high boiling point hydrocarbon and fuelled by slightly enriched uranium. The City of Piqua, under a separate agreement with the Commission, would provide the site near its existing steam power station on the Great Miami River and the conventional turbo-generating and relating facilities.

The total estimated cost to the Commission under the proposed arrangement would be about 12,300,000 dollars. This would include the cost of research and development, construction, training, test operation, and operating costs to be borne by the Commission. The conventional facilities which would be provided by Piqua have been valued by the city at about 4,000,000 dollars. It is expected that the reactor would be completed by July, 1961. Title to the entire reactor plant and the fuel elements would be retained by the U.S. Government. Since the plant would be built and operated under contract to the A.E.C., it is not expected that formal Commission construction or operating licences would be issued, but authority to operate the plant would be granted only after the Commission's safety standards have been fully complied with. The original proposal was submitted in response to the second invitation issued under the Commission's Power Demonstration Programme designed to bring the resources of industry into the development of engineering information on the performance of nuclear power plants.

Personal and Business

Appointments

MR. J. J. BOEX has been appointed a director of the British Aluminium Company, Ltd.

MR. JAMES A. DEWHIRST has been appointed director and general manager of Midgley and Sutcliffe, Ltd.

MR. G. V. PALMER, a director of Winget, Ltd., has been appointed chairman of council of the Institute of Export.

MR. FRANCIS GEORGE FLEURY has been elected president of the Royal Institution of Chartered Surveyors.

MR. G. A. DWYER has been appointed assistant export sales manager of the Marconi International Marine Communication Company, Ltd.

MR. M. O. L. LYNTON has been appointed a director of Soag Machine Tools, Ltd. Mr. David Dixon has been appointed publicity manager.

VICE-ADMIRAL SIR FRANK MASON, M.I.Mech.E., M.I.Mar.E., has been appointed to succeed Sir Andrew McCance as chairman of the Mechanical Engineering Research Board.

THE MINISTRY OF SUPPLY has announced that Mr. R. G. Friend has been appointed director of electronics research and development (telecommunications) in succession to Brigadier J. D. Haigh.

THE MACHINE TOOL TRADES ASSOCIATION announces that Mr. W. J. Morgan, general manager of the Association, is to retire on June 30, but that his services have been retained in the non-executive capacity of adviser from that date. Mr. H. O. Barrett will assume the overall responsibility for the Association affairs with effect from July 1.

SAMUEL FOX AND CO., Ltd., has announced the following appointments :—Mr. H. Morley, deputy general works manager ; Mr. R. Swinden, works manager (services) ; Mr. F. C. G. Harris, works manager, light departments ; Mr. E. V. Ward manager of the cold rolled strip department. The following appointments will become effective on July 1 :—Mr. J. Brockbank, fuel officer ; Mr. A. Crossley, manager of the wire and bright bar department, and Mr. K. C. P. Wattsford, manager of the steel treatment department.

Business Announcements

MR. D. A. MALTHA has retired after representing Head Wrightson and Co., Ltd., in Holland, for thirty years.

THE DOWTY GROUP, Ltd., has announced the formation of a new company, Dowty Mining Developments, Ltd., Ashchurch, near Tewkesbury.

BRITISH ERMETO CORPORATION, Ltd., Beacon Works, Hargrave Road, Maidenhead, Berks, states that its telephone number is Maidenhead 5100.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has opened a new store and sales offices at 67–77, Holloway Head, Birmingham, 1 (telephone Midland 6922).

LANDIS MACHINE-MAIDEN, Ltd., Hyde, Cheshire, is a new company formed by Landis Machine Company, Waynesboro, U.S.A., and Maiden and Co., Ltd., Hyde, Cheshire.

MR. L. E. HUNTER, M.I.C.E., M.I.Struct.E., states that he is now occupying offices at 123, Victoria Street, London, S.W.1, and practising as L. E. Hunter and Partners, undertaking civil and structural engineering.

PHILIPS ELECTRICAL, Ltd., states that its north-east region offices and showrooms are now located at 72, Wellington Street, Leeds, 1, and the trade counter and stores at 2, Britannia Street, Leeds, 1 (telephone, Leeds 36141).

MORTIMER ENGINEERING COMPANY, 204–206, Acton Lane, Harlesden, London, N.W.10, announces that it has been appointed distributor and stockist in the United Kingdom of "Bammesberger" special-purpose machines and drilling heads.

Contracts

THE GOVERNMENT OF THE BELGIAN CONGO has placed an order with International Aeradio, Ltd., for a number of control consoles for the air traffic control towers of seven airports in the Belgian Congo.

MATTHEW HALL AND CO., Ltd., has received a contract for the mechanical engineering design of the synthetic rubber plant to be constructed at Pernis refinery, Holland, for the Royal Dutch/Shell Group. The plant will have a capacity of at least 50,000 tons per annum.

MIRRLEES, BICKERTON AND DAY, Ltd., has received from the Ashanti Goldfields Corporation, Ltd., a contract for a KVSS16 industrial diesel engine developing 4128 b.h.p. at 428 r.p.m., which will be direct-coupled to a Brush alternator giving 2950kW power output.

HUDSWELL, CLARKE AND CO., Ltd., has received from the Crown Agents for Oversea Governments and Administrations a contract for a further eight main line diesel hydraulic locomotives for the Sierra Leone Government Railway. This order brings the number of locomotives the company is now building for the railway up to sixteen, the total value of the contract being approximately £500,000.

HEENAN AND FROUDE, Ltd., Worcester, is to supply more than 120 tubular air coolers to The English Electric Company, Ltd., for use in the American Priest Rapids dam. The coolers will be used for the closed circuit ventilation and for the cooling of the ten vertical-shaft water-turbine alternators. Heenan and Froude, Ltd., has also secured a contract from The English Electric Company, Ltd., for tubular coolers for the lubricating oil of the main thrust blocks of these sets.

THE HARLAND ENGINEERING (AUSTRALIA) PTY., Ltd., of Melbourne, is to supply and erect the equipment to be installed in the Keepit power station and associated substation of the Electricity Commission of New South Wales. The plant comprises a 6000kW hydro-electric generating unit, valves, pumping equipment, crane, draught-tube gates, transformer, switchgear, control gear, remote supervisory equipment, batteries and cables. The power station is being built at the foot of Keepit dam, which spans the Namoi River, approximately 200 miles due north of Sydney.

Miscellanea

OIL COMPANY'S DEVELOPMENTS.—The British Petroleum Company, Ltd., announces that construction of a 25,000 barrels per day oil refinery for B.P. Canada, Ltd. has commenced on the island of Ville D'Anjou, Montreal, and that the new tanker jetty at Finnart, Loch Long, will be completed in September.

FLAME-RETARDING POLYTHENE EQUIPMENT WIRE.—British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1, has announced the introduction of a range of sizes of equipment wire insulated with flame-retarding polythene, which is particularly suitable for e.h.t. leads to cathode-ray tubes.

MINING MACHINERY EXHIBITION.—The Council of Underground Machinery Manufacturers announces that an exhibition of the industry's products is to be held at Olympia (Grand Hall) from July 9 to 18 next year (1959). In addition to the displays by members of the Council and other manufacturers a three-day symposium of shaft sinking and tunnelling is being arranged by the Institution of Mining Engineers.

MR. VINCENT DELPORT.—We have learned with regret of the death of Mr. Vincent Delport, which occurred on June 3. Mr. Delport, who was sixty-nine, was managing director of the Penton Puolishing Company, Ltd., for thirty years until his retirement in 1956. He was well known throughout the foundry industry in this country and in the U.S.A., and in the early years of his professional career had practised as a consulting engineer in Paris.

PNEUMATIC CONTROL EQUIPMENT.—The Maxam Division of the Holman Group has produced a film on the application of pneumatic and associated equipment for the automatic control of production processes. It is called "A Measure of Maxam" and starts with the manufacture and assembly of "Maxam" valves, cylinders and solenoids. It goes on to deal with a number of applications of the equipment to demonstrate its versatility and flexibility.

USE OF RADIOISOTOPES IN AUSTRALIA.—The first large scale field use of radioactive isotopes in Australia took place recently in an investigation of the design of power station cooling ponds. The Australian Atomic Energy Commission and the Electricity Commission of New South Wales co-operated in the experiments, which will provide design data for the cooling ponds for the very large power stations planned for the New South Wales coalfields. The experiment was conducted at the 20MW power station at Maitland, which uses a former reservoir as a cooling pond. The circulation of the water in this reservoir was traced by the addition of radioactive iodine to the warm water fed into the reservoir from the power station.

MOTIVE POWER DEPOT AT THORNABY.—A new motive power depot of the North Eastern Region of British Railways which has been opened at Thornaby is one of the largest and most modern in the country and is capable of handling up to 220 large locomotives. The depot will mainly serve steam locomotives for the present, but it has been designed to facilitate easy conversion for use by the largest of the proposed new diesel and electric locomotives. It includes a large octagonal shed with twenty-two stalls and a 70ft turntable, a straight shed with six roads 265ft long, and a repair shop with five roads of similar length, together with a machine bay, wheel dropping and weighing facilities.

SAFETY MAT FOR FACTORY USE.—An industrial safety mat to replace duckboards in factories, machine shops, and other industrial establishments is now made by James Walker, Ltd., Lion Works, Woking, Surrey. This mat is moulded from a special composition $\frac{3}{4}$in thick and has a flat base, its top surface being provided with longitudinal grooves $\frac{1}{4}$in deep. Standard mats 4ft long by 2ft wide can be joined end to end to form any required length 2ft wide. The composition is such that it provides a non-slip top surface with a skid-proof base ; it resists oils, greases and water ; gives a high degree of vibration absorption, and is durable, tough and flexible. The mats are available in six different colours and they can be provided with inlaid letters or symbols for identification of ownership if required.

INDUSTRIAL MOBILE DEMONSTRATION UNIT.—A specially fitted mobile demonstration unit put into service by Kelvin and Hughes (Industrial), Ltd., has left this country for a four-months' tour of Eastern European countries. This new unit will enable the industrial division of the firm to give on-site demonstrations of equipment incorporating modern developments in the field of industrial process control. The instruments will include high frequency recording equipment, ultrasonic non-destructive testing equipment, boiler-house measuring and process control instruments, a shadowless operating theatre light-fitting, &c. The demonstration vehicle is a 27ft semi-trailer drawn by a six-cylinder diesel-engined Thames "Trader," which has been slightly modified to include a power take-off for the electrical generating equipment in the form of a 230V, 12kVA alternator which makes the unit independent of mains electricity supplies.

SINTERED OXIDE CUTTING TOOLS.—In a paper recently read before the Midland Region of the Institution of Production Engineers, Mr. H. Eckersley and Mr. R. N. Cook of Wickman, Ltd., gave as one of the objects of their current sintered oxide research programme the evaluation of power consumption at extremely high speeds. Valuable information on this point was obtained by a recent test cut with "Wimet" sintered oxide tools at 26,100ft per minute at 0·0053in feed and 0·020in depth of cut. The material was a billet of EN 8 (0·040 per cent carbon steel) in the 40-ton condition. This cut followed two previous cuts, at 13,650ft and 16,350ft per minute, and gave a metal removal rate of 33·3 cubic inches per minute. It had been thought that once a certain speed had been attained the power consumption would remain constant or decrease, but the test showed that this is not the case at speeds up to about 30,000ft per minute. If the power consumption curve does flatten out, then it will only be at speeds appreciably higher than this.

SYNTHETIC DETERGENTS IN SEWAGE.—The publication of the White Paper covering the work of the Cremer Committee on the subject of synthetic detergents in sewage, has focused attention on the fact that most, if not all, of the synthetic detergents at present in use, cannot be broken down by sewage bacteria and hence persist in sewage and sewage effluents, giving rise to various foaming problems. A new range of synthetic detergents based upon sucrose esters, i.e. combinations of sugar and edible fatty acids, appears likely to assist in overcoming this particular problem. These products are simple carboxylic esters of sucrose and it would be anticipated, by analogy with similar materials such as fats and fatty oils, that ready breakdown would occur in the presence of the normal sewage bacteria. Research work is now in progress to establish whether this hypothesis is, in fact, correct. One of these materials, sucrose stearate, has already been shown by laboratory tests to have interesting properties as a scouring agent for both synthetic fibres and wool and to have good detergency power. These materials were initially developed by the Sugar Research Foundation in the U.S.A., who have taken out various patents in connection with them, for which Howards of Ilford, Ltd., who had done considerable work on parallel lines, is now the licensee in this country.

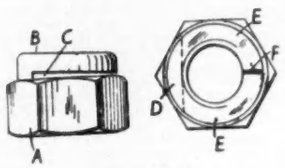
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

BOLTS AND NUTS

795,203. July 16, 1955.—SCREW-THREADED NUTS, Guest Keen and Nettlefolds (Midlands), Ltd., Box No. 24, Heath Street, Birmingham, 18. (*Inventor: James Joseph Griffiths.*)

The invention relates to the class of nuts known as "stiff" nuts, which are designed to resist any



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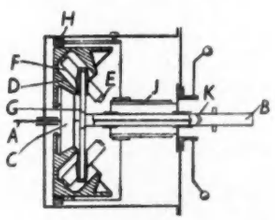
tendency towards slackening when in use, such as when subject to vibration. The nut shown in the drawings comprises a body *A* which has an extension *B* at one end and, in this extension there is a slot *C* at right angles to the axis of the nut. The slot extends across the threaded bore to the major diameter of the thread. This cut extends for approximately three-quarters of the circumference of the extension and leaves a substantial buttress area *D*. The two wings *E* are formed by making a second slot *F* in a plane passing through the axis of the nut. These two wings are then pressed towards the body of the nut and also towards the axis of the nut. The thread extends through the body and the wings and is of the same form throughout.—*May* 21, 1958.

POWER TRANSMISSION

795,234. August 30, 1954.—STEPLESS VARIABLE EPICYCLIC FRICTION GEARBOX, Max Weber, Haupttrasse 73, Mühlhofen am Bodensee, Germany.

The invention relates to a gearbox in which the planet wheels are rolling friction cones, variation of the speed ratio being achieved by displacement of an annulus into frictional engagement with rolling circles of different diameters on the rolling friction cones. In the construction shown in the drawing, a driving shaft *A* is mounted in bearings where it enters the casing, its forward end being freely supported within



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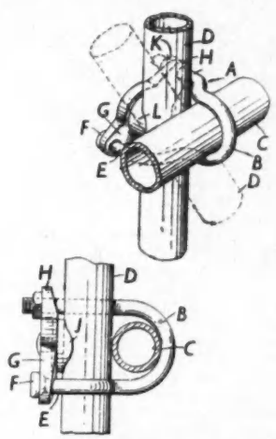
the gearbox inside a hollow, driven shaft *B*. Fixed on the driving shaft is a bevelled driving wheel *C* which frictionally engages a skirting on each cone *D*. The cones are mounted on pins *E* which revolve in bearings *F* supported on revolving arms *G* secured to the inner end of the driven shaft *B*. Preferably, as shown in the drawing, the angle at the vertex of each cone is a right angle and the cone bearings *F* are set on the revolving arms *G* at an angle of 45 deg. The pins *E* are axially displaceable within their bearings *F*. The surfaces of the cones engage a non-rotatable friction annulus *H* which can be shifted coaxially with the shaft *B* so as to engage circles of different diameter on the cones *D*. To this end the annulus *H* is slidably supported on a splined central sleeve *J*. In the position of the annulus *H* shown in the drawing, it engages the smallest rolling circle on the cones and would therefore cause the cones to circle around the central shaft at a slow speed and transmit this speed to the driven shaft *B* through the supporting arms *G*. The driven shaft *B* is divided into two members by a torsion coupling *K* which creates an axial thrust that varies in proportion with the torque transmitted. Therefore, if the driven load is high and a high torque is transmitted through the coupling, it will push the inner member of the driven shaft into the gearbox to the left and press the engaging surfaces of the cones against the annulus *H* and the bevelled driving wheel *C*. Owing to the displaceability of the cones in their journal bearings, this axial thrust will create radial components across the frictionally engaging surfaces and the cones will adjust themselves in their bearings until a proper equilibrium between the radial loads has been established. It will be understood that the radial pressure with which the cones bear upon the co-operating members of the friction gearing depends upon the magnitude of the torque that is transmitted to the inner member of the driven shaft *B*, whereas the power delivered to the gearbox by the driving shaft *A* produces only tangential forces between the engaging surfaces of the co-operating members. Modified designs are also shown in the specification.—*May* 21, 1958.

STRUCTURAL ENGINEERING

795,200. June 29, 1955.—SCAFFOLDING CLAMPS, Kirk and Co. (Tubes), Ltd., 74, Paradise Street, London, S.E.16, and Roland James Latham, of the company's address.

Referring to the drawing, one form of the clamp is shown, incorporating a bridge piece fitted with a rotatable bearing boss to permit the angularity of the adjustable scaffold member to be varied infinitely between 0 deg. and 90 deg. According to this embodiment, the clamp comprises a rod-like tie member *A* which is substantially U-shape and is adapted by its outer semi-circular looped end *B* to embrace and positively locate a horizontal scaffold member *C*. The side limbs of the "U" are offset from the closed end of the "U" so that, as clearly shown in the lower view, the limb at one side of the tie member is at a higher level than the limb at the other side of the scaffold member *D*. The end *E* of one limb has a swivel connection *F*, with a bridge piece *G*, which engages in a recess in the bridge. The bridge has a hook *H* at its other end for engagement over the end of the other limb which is fitted with a nut which, when tightened, urges the bridge



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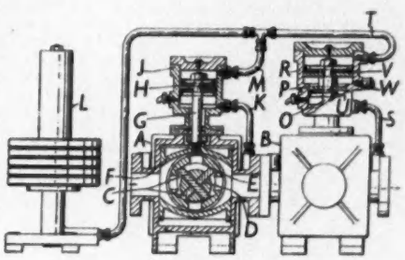
against the member *D* which bears against the member *C* so as to clamp the two tightly together at their point of intersection. The bridge is fitted with a rotatable bearing boss *J*, the face of which is opposed to the scaffold member *D*. It will be seen that by slackening the nut, the member *D* can be swung through an angle of approximately 90 deg. before it engages both of the side limbs of the tie. Thus, it can be moved and locked in any desired position between these two extremities.—*May* 21, 1958.

PUMPS

795,360. August 31, 1955.—VARIABLE-CAPACITY ROTARY PUMPS, Plenty and Son, Ltd., a British company, Eagle Iron Works, Newbury, Berkshire. (*Inventor: Guy Taite Shoosmith.*)

The invention relates to variable-capacity rotary pumps, particularly pumps of the sliding vane type. According to the invention, for the constant pressure control of two or more pumps, connected together in series, a single accumulator is used to control all the control members, the pressure exerted by the accumulator being transmitted to each control member through load-transmission means which transform the pressure into loads which are related to each other in the same way as are the desired delivery pressures of the pumps. As the drawing shows, the installation comprises a pair of pumps *A* and *B* connected together in series, the pump *A* being a low pressure pump which delivers its output to the high pressure pump *B*. The pumping chambers of both pumps are substantially the same, so that only the pump *A* is shown in cross-section. It will be seen that the pumps have vanes *C* which slide in slots in a rotor shaft *D*. The outer ends of the vanes bear on surfaces formed on the rotor proper *E* which is mounted for rotation in a sliding block *F*. Movement of the block up or down varies the capacity of the pump. In order that the capacities of the pumps may be controlled, the sliding block *F* of the pump *A* is provided with a rod *G* connected to a piston *H* in a cylinder *J* which at its lower end is in communication with the delivery side of the pump through a pipe *K* and at its upper end is in communication with a hydraulic accumulator *L* through a pipe *M*. Similarly, the pump *B* is provided with a piston rod *O* connected to a piston *P* in a cylinder *R* which at its lower end is in communication with the delivery side of the pump through a pipe *S* and at its upper end is in communication with the accumulator *L* through a pipe *T*. Thus, a single accumulator is provided for both pumps. In the control cylinder *J* of the low pressure pump *A*, the double-acting piston *H* is of equal area on both sides. Equilibrium therefore occurs when the pump delivery pressure equals the accumulator pressure. In the control cylinder *R* of the high pressure pump *B*, however,



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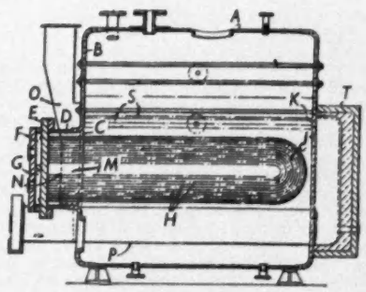
the double-acting piston *P* consists of a small piston *U* and a large piston *V*, this piston being subjected to the accumulator pressure, while the smaller piston *U* is subjected to the pump delivery pressure. Accordingly, equilibrium occurs when the ratio of the pump delivery pressure to the accumulator pressure is equal to the ratio of the area of the face of the large piston *V* and the face of the small piston *U*. For any given accumulator pressure, the load exerted by it on the control members *G* and *O* of the two pumps *A* and *B* is strictly in proportion to the ratio of the area of the piston faces on which it acts. If, therefore, the areas of the piston faces on which the pump delivery pressures act are equal, the pumps will be kept working at pressures which are in the same ratio as are the areas of the piston faces on which the accumulator pressure acts. By varying the pressure of the accumulator the pump pressures are varied but their ratio remains the same. The space between the two pistons *U* and *V* in the pump *B* can be open to atmosphere or to drain but is preferably connected through the port *W* to a small hydraulic oil tank serving to maintain lubrication on both sides of the pistons. The two pumps can be driven by a common shaft, but this is not essential. Nor is it essential that the pumps be driven by a common motor. They must, of course, be in reasonable synchronism but absolute synchronism is not necessary as slight speed variation is taken care of by the constant pressure control on each pump.—*May* 21, 1958.

STEAM GENERATORS

794,893. May 15, 1953.—STEAM GENERATORS OF THE STEAM TRANSFORMER TYPE, John Thompson Water Tube Boilers, Ltd., Ettingshall Engineering Works, Wolverhampton. (*Inventor: Gilbert Ashton Plummer.*)

The invention relates to steam transformers of the type comprising a vessel or drum having within a nest of tubes adapted to be supplied with high pressure steam and to be immersed in water contained within the drum, the high pressure steam being



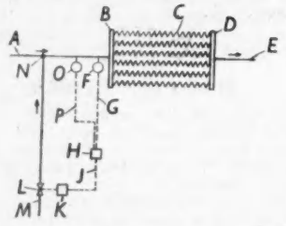
No. 794,893

employed as a heating medium to heat up the water in the drum and generate steam at a relatively low pressure. An object of the invention is to provide an improved steam transformer of the type specified which may still be employed for generating low pressure steam when, for any reason, the consumption

of high pressure steam directly from the ship's main boilers is undesirable or impossible, while being of an overall size not substantially greater than that of existing steam transformers of an equivalent capacity. Referring to the drawing, a steam transformer has a main drum *A* and in the front wall there is a circular aperture *C*, into which there is secured the rear end of a cylindrical wall *D* which carries at its front end a tube plate *E*. The tube plate constitutes the rear wall of two headers *F* and *G*, of *D*-shape, the upper header *F* of which may be supplied with high pressure heating steam and from the lower header *G* of which the spent steam is exhausted. Between the upper and lower headers there are heating tubes *H* of hair-pin form, having their bends *J* close to the rear wall *K* of the drum. The normal water level in the drum is such that the upper limbs of the heating tubes *H* are submerged to an appropriate depth. Between the front wall *B* of the drum *A* and an appropriate cylindrical wall and end plate, indicated at *M* and *N*, is defined a substantially saddle-shaped smokebox *O*, the end plate *N* of which has an aperture in which is secured the tube plate *E*. In the lower parts of the front and rear walls of the drum are circular apertures in which are secured the appropriate end parts of a tube *P* of moderate diameter, extending forward beyond the front wall of the drum for a short distance to constitute a comparatively small combustion chamber having an oil burner mounted therein. This burner is of a known vaporising or other type which will burn oil fuel with a substantially non-luminous flame. The front and rear walls of the drum are suitably drilled over areas located one at either side of the nest of steam heating tubes so that each of these walls constitutes a tube plate for two series of fire tubes *S*. These fire tubes extend substantially horizontally and their front ends are open to the space within the smokebox *O*. The rear ends of the fire tubes discharge into a hood *T* on the rear end of the drum. Another arrangement is also shown in the specification.—*May* 14, 1958.

795,381. December 23, 1954.—REGULATING THE TEMPERATURE OF SUPER-HEATED STEAM IN A STEAM GENERATOR, Sulzer Frères, Société Anonyme, Winterthur, Switzerland.

In the steam generator arrangement shown in the drawing, the incoming steam flows through a pipe *A* into a collector *B* and thence into a superheater consisting of a bank of parallel tubes *C*. After being superheated in these tubes the steam passes into a collector *D* and then into a pipe *E*. The temperature of the incoming steam is sensed by a temperature-sensitive element *F* disposed at or near the inlet end of the superheater, for example, just before the collector *B* as shown. Signals from the temperature-sensitive element *F* are conducted through a connection *G* to a proportional controller *H* which converts them into regulating values. The regulating values produced by the controller *H* are transmitted through a connection *J* to a regulating



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motor *K*. The motor actuates a valve *L*, through which variable amounts of water can be injected from a pipe *M* into the steam pipe *A* at the point *N*, before the superheater, the temperature-sensitive element *F* and a steam flow meter *O*. In cases where the signals from the temperature-sensitive element *F* are suitable to act as the regulating values without conversion, the proportional controller *H* may be omitted and these signals transmitted directly to the regulating motor *K* of the injection valve *L*. The regulating device is also subjected to another influence, namely, the total amount of steam flowing through the superheater. This other influence is arranged to originate controlling signals which act practically instantaneously on the regulating motor *K* in the same way as the signals received from the temperature-sensitive element *F*. For determining the amount of steam flowing through the superheater there is the steam flow meter *O*, signals from which are conducted to the controller *H* through a connection *P*. The transmission of the signals and the regulating values can be conducted in any convenient manner hydraulically, pneumatically or electrically. The regulating system is equally suitable for use with boilers employing natural or forced flow, as well as in steam generators designed for operation at super critical pressure and temperature conditions, and steam generators in which, on account of the size and capacity of the furnaces, the working medium is divided between two or more tube systems, each with its own regulating system.—*May* 21, 1958.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

COLD-REDUCED TINPLATE AND COLD-REDUCED BLACKPLATE

No. 2920 : 1957. Price 4s. 6d. Tinplate and blackplate delivered in sheet form for the United Kingdom home trade are the subject of this standard. It deals with the following materials manufactured by the cold-reduction process, in " substances " of from 70 lb to 196 lb per basis box : cold-reduced hot-dipped tinplate ; cold-reduced electrolytic tinplate ; and cold-reduced blackplate. It does not deal with tinplate manufactured by the hot-pack rolling process.

The specification contains clauses on : freedom from defects ; dimensions ; weight tolerances ; quality of tin ; tin coating and its weight ; mechanical properties. There is also a clause on packaging and identification which includes eight items of information to be marked on each package ; and there are—in a related Appendix—two diagrams illustrating the current bulk package for hot-dipped and electrolytic tinplate respectively. The volumetric method for determining the weight of tin coating (iodine titration) is also detailed in an Appendix.

STEEL TUBES AND TUBULARS SUITABLE FOR SCREWING TO B.S. 21 PIPE THREADS

No. 1387 : 1957. Price 6s. In this standard three thicknesses of tubes are specified—light, medium and heavy—with nominal bores of $\frac{1}{4}$in to 6in inclusive.

The new publication differs from the 1947 edition in several respects. The minimum outside diameter for medium and heavy tube is the same as the maximum diameter of internal thread and therefore slightly less than for classes B and C. The total outside diameter tolerances for medium and heavy tube of 1in, 1$\frac{1}{4}$in, and 1$\frac{1}{2}$in nominal bore have been decreased from 0·031in to 0·030in. The tolerance for tube of 2in nominal bore has been decreased from 0·045in to 0·040in and that for tube of 2$\frac{1}{2}$in nominal bore from 0·050in to 0·045in.

Some of the thicknesses of both heavy and medium tube have been increased by one standard wire gauge and some decreased by one or two gauges. The weights per foot of both plain-end and screwed and socketed tubes are the ISO agreed values, and the ISO recommendation that there should be no limit on the plus tolerance on thickness has been adopted. The weight tolerance on a single tube has also been altered from minus 7$\frac{1}{2}$ per cent, to minus 8 per cent plus 10 per cent, in conformity with the ISO recommendation. The random lengths now specified are 13ft minimum, and new identification colours have been adopted for the medium and heavy tubes.

BRITISH STANDARD FOR COTTON BELTING DUCKS

No. 1069 : 1957. Price 4s. The cotton ducks specified in the second edition of this standard are described in terms of a 42in nominal width, the range including 28 oz, 32 oz, 36 oz and 42oz soft types and 31 oz and 33$\frac{1}{3}$ oz hard types. General requirements, constructional particulars, tensile strengths and elongations are specified, as are methods of test for assessing compliance with the standard.

ANODISED ALUMINIUM

No. 1615 : 1958. Price 7s. 6d. This revised specification brings the methods of test into line with current practice and includes requirements for additional properties. Further, the method of expressing the grade of material for specular reflectors for white light has been altered in order to make the standard more widely applicable.

The abrasion test has been revised in the light of past difficulties experienced in its operation ; and the dimensions of the test jet have been more closely specified. The Bengough-Stuart chromic acid anodic film has not been found a suitable standard for comparison of coatings produced in sulphuric acid, nor has it been possible to find any other suitable standard specimen. The present test is, therefore, only comparative, and identical results may not be obtainable on different pieces of apparatus. Work aimed at improving the reproducibility of the test is continuing, and users are invited to communicate their experiences to B.S.I. The foreword emphasises that it is not possible for one single coating to meet all the requirements of the standard, as individual requirements may be incompatible.

Catalogues

HADFIELDS, Ltd., East Hecla Works, Sheffield, 9.—Illustrated publication describing extrusion press components.

DENFORD SMALL TOOLS (BRIGHOUSE), Ltd., Victoria Works, Birds Royd, Brighouse, Yorks.—Leaflet giving details of an edge tool sharpening machine.

METAL AND PIPELINE ENDURANCE, Ltd., Artillery Mansions, Victoria Street, London, S.W.1.—Illustrated brochure giving details of " Mapel " welding inspection service.

G. AND J. WEIR, Ltd., Cathcart, Glasgow.—Illustrated folder describing the " Robot " two-element boiler feed regulator for the control of feed make-up to accord with boiler evaporation in water-tube boilers.

THE STANDARD AND POCHIN BROS., Ltd., Evington Valley Road, Leicester.—Publication No. 177, illustrating and describing P.R. " Uniform " pulley-mounted centrifugal fans. Performance tables are included.

RENOLD CHAINS, Ltd., Renold House, Wythenshawe, Manchester.—Catalogue No. 116/130, describing a standardised range of chain drives up to 4000 h.p. A simple coloured selection chart is also included.

PATERSON HUGHES ENGINEERING COMPANY, Ltd., Wyndford Works, Maryhill, Glasgow.—Section I of a catalogue describing some of the materials handling schemes which have been designed, manufactured and installed by the company.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., Automotive and Industrial Products Division, Hanham Road, Kingswood, Bristol.—Booklet entitled " More Power to Your Elbow with Pneumatic Equipment," containing details of the pneumatic equipment available in Great Britain.

CREED AND CO., Ltd., Telegraph House, Croydon, Surrey.—Illustrated folder describing the " Model 25 " multi-wire reperforator, an output punch for electronic digital computers, and office machines. This unit is now available for six and seven-track tape punching and can also punch two tapes simultaneously if required.

MATTHEWS AND YATES, Ltd., Cyclone Works, Swinton, Manchester.—Fourth edition of a catalogue containing full details, performance tables and dimensions of " Cyclone Multivane " and paddle blade fans. The catalogue, which contains 124 pages, has been designed to assist engineers in selecting the correct type and size of centrifugal fan equipment for any given requirement.

MULLARD, Ltd., Mullard House, Torrington Place, London, W.C.1 (Government and Industrial Valve Division).—Brochure containing data and application notes for QQV03–20A and QQV06–40A double tetrode transmitting valves. The sections cover design features, performance and modes of operation, data tables and curves, applications, notes and basic transmitter stages. Leaflet listing high-voltage xenon and mercury vapour rectifiers. Individual data sheets, together with general operational recommendations for instrument type cathode-ray tubes.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH COMPUTER SOCIETY

Mon., June 16.—Northampton College of Advanced Technology, St. John Street, London, E.C.2, Annual General Meeting, 5.30 p.m.; Presidential Address, M. V. Wilkes, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, June 13, *and Sat., June* 14.—EASTERN BRANCH : Summer Meeting at Colchester.

Sat., June 14.—LONDON AND SOUTHERN BRANCHES GRADUATES' SECTIONS : Joint Summer Meeting at Portsmouth.

Wed., June 18.—ORDINARY MEETING : Reardon Smith Lecture Theatre, Cardiff, " Light Mechanical Engineering in South Wales," H. A. V. Bulleid ; " Some Mechanical Equipment in the Heavy Industries of South Wales," W. F. Cartwright, and I. S. Scott-Maxwell, 10.30 a.m. ★ SOUTHERN BRANCH : Visit to United States Air Force Base, Greenham Common, Berks, 10 a.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

To-day, June 13.—Caxton Hall, Westminster, London, S.W.1, Summer Meeting ; Annual General Meeting, 4.45 p.m. " Hogsmill Valley Works of the Hogsmill Valley Joint Sewerage Board," 6 p.m.

PHYSICAL SOCIETY

Wed., June 18.—COLOUR GROUP : Afternoon Visit to the Paints Division, Imperial Chemical Industries, Ltd., Slough, Bucks.

ROYAL METEOROLOGICAL SOCIETY

Wed., June 18.—49, Cromwell Road, London, S.W.7, " The Measurement of Gustiness in the First Few Thousand Feet of the Atmosphere," J. I. P. Jones and H. E. Butler ; " The Use of Balloons in Atmospheric Pollution Research," D. H. Lucas, G. Spurr and F. Williams ; " A Simple Grating Spectrometer for Sky-Emission Studies," R. M. Goody ; " The Hydrogen Content of Atmospheric Air at Sea," E. Glueckauf and G. P. Kitt ; and " A Direct Measurement of Infra-Red Radiation Divergence to 160 mb," V. E. Suomi, D. A. Staley and P. M. Kuhn, 5 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., June 18.—Central Electricity Authority Headquarters, Winsley Street, London, W.1, Annual General Meeting, 6.45 p.m.

Advanced Engineering Courses

Applications of Computers. THE UNIVERSITY OF NOTTINGHAM, DEPARTMENT OF MECHANICAL ENGINEERING, University Park, Nottingham. One week's residential course, Monday to Friday, September 15 to 19. Course, including notes, ten guineas. Accommodation, eight guineas.

The Design of Industrial Experiments. THE UNIVERSITY OF BIRMINGHAM, INSTITUTE FOR ENGINEERING PRODUCTION, " Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course, Monday to Friday, June 30 to July 4. Fee thirty guineas.